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<p>(54) Title: ANTAGONISTS FOR TREATMENT OF CD11/CD18 ADHESION RECEPTOR MEDIATED DISORDERS</p> <p style="text-align: center;"><b>LYMPHOCYTE RECRUITMENT</b></p> <p>(57) Abstract</p> <p>Compounds of the general structure D-L-B-(AA), for example (A), that are useful for treating Mac-1 or LFA-1-mediated disorders such as inflammatory disorders, allergies, and autoimmune diseases are provided.</p>		

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## ANTAGONISTS FOR TREATMENT OF CD11/CD18 ADHESION RECEPTOR MEDIATED DISORDERS

### Field of the Invention

5 This invention relates to methods and therapeutic compositions for treating mammals, preferably humans, who suffer from or are susceptible to (CD11/CD18) adhesion receptor mediated disorders, especially leukocyte LFA-1 mediated disorders. In particular, it relates to methods for ameliorating or modulating immune responses such as those caused by inflammation, autoimmune responses and host-graft rejection, as exemplified by psoriasis, rheumatoid arthritis, asthma, multiple sclerosis, rejection following transplanted grafts and the like.

### 10 Background of the Invention

#### Inflammation

Human peripheral blood is composed principally of red blood cells, platelets and white blood cells or leukocytes. The family of leukocytes are further classified as neutrophils, lymphocytes (mostly B- and T-cell subtypes), monocytes, eosinophils and basophils. Neutrophils, eosinophils and basophils are sometimes referred to as "granulocytes" or "polymorphonuclear- (PMN) granulocytes" because of the appearance of granules in their cytoplasm and their multiple nuclei. Granulocytes and monocytes are often classified as "phagocytes" because of their ability to phagocytose or ingest micro-organisms and foreign mater referred to generally as "antigens". Monocytes are so called because of their large single nucleus and these cells may in turn become macrophages. Phagocytes are important in defending the host against a variety of infections and together with lymphocytes are also involved in inflammatory disorders. The neutrophil is the most common leukocyte found in human peripheral blood followed closely by the lymphocyte. In a microliter of normal human peripheral blood, there are about 6,000 leukocytes, of which about 4,000 are neutrophils, 1500 are lymphocytes, 250 are monocytes, 150 are eosinophils and 25 are basophils.

25 During an inflammatory response peripheral blood leukocytes are recruited to the site of inflammation or injury by a series of specific cellular interactions (see Fig. 1). The initiation and maintenance of immune functions are regulated by intercellular adhesive interactions as well as signal transduction resulting from interactions between leukocytes and other cells. Leukocyte adhesion to vascular endothelium and migration from the circulation to sites of inflammation is a critical step in the inflammatory response (Fig. 1). T-cell lymphocyte immune recognition requires the interaction of the T-cell receptor with antigen (in combination with the major histocompatibility complex) as well as adhesion receptors, which promote attachment of T-cells to antigen-presenting cells and transduce signals for T-cell activation. The lymphocyte function associated antigen-1 (LFA-1) has been identified as the major integrin that mediates lymphocyte adhesion and activation leading to a normal immune response, as well as several pathological states (Springer, T.A., *Nature* 346:425-434 (1990)). Intercellular adhesion molecules (ICAM) -1, -2, and -3, members of the immunoglobulin superfamily, are ligands for LFA-1 found on endothelium, leukocytes and other cell types. The binding of LFA-1 to ICAMs mediate a range of lymphocyte functions including

lymphokine production of helper T-cells in response to antigen presenting cells, T-lymphocyte mediated target cells lysis, natural killing of tumor cells, and immunoglobulin production through T-cell-B-cell interactions. Thus, many facets of lymphocyte function involve the interaction of the LFA-1 integrin and its ICAM ligands. These LFA-1:ICAM mediated interactions have been directly  
 5 implicated in numerous inflammatory disease states including; graft rejection, dermatitis, psoriasis, asthma and rheumatoid arthritis.

While LFA-1 (CD11a/CD18) on lymphocytes plays a key role in chronic inflammation and immune responses, other members of the leukocyte integrin family (CD11b/CD18, CD11c/CD18 and CD11d/CD18) also play important roles on other leukocytes, such as granulocytes and  
 10 monocytes, particularly in early response to infective agents and in acute inflammatory response.

The primary function of polymorphonuclear leukocytes, derived from the neutrophil, eosinophil and basophil lineage, is to sense inflammatory stimuli and to emigrate across the endothelial barrier and carry out scavenger function as a first line of host defense. The integrin Mac-1(CD11b/CD18) is rapidly upregulated on these cells upon activation and binding to its  
 15 multiple ligands which results in the release of oxygen derived free radicals, protease's and phospholipases. In certain chronic inflammatory states this recruitment is improperly regulated resulting in significant cellular and tissue injury. (Harlan, J. M., *Acta Med Scand Suppl.*, 715:123 (1987); Weiss, S., *New England J. of Med.*, 320:365 (1989)).

#### LFA-1 (CD11a/CD18) and Mac-1 (CD11b/CD18)

20 The (CD11/CD18) family of adhesion receptor molecules comprises four highly related cell surface glycoproteins; LFA-1 (CD11a/CD18), Mac-1 (CD11b/CD18), p150.95 (CD11c/CD18) and (CD11d/CD18). LFA-1 is present on the surface of all mature leukocytes except a subset of macrophages and is considered the major lymphoid integrin. The expression of Mac-1, p150.95 and CD11d/CD18 is predominantly confined to cells of the myeloid lineage (which include neutrophils,  
 25 monocytes, macrophage and mast cells). Functional studies have suggested that LFA-1 interacts with several ligands, including ICAM-1 (Rothlein et al., *J. Immunol.* 137:1270-1274 (1986), ICAM-2, (Staunton et al., *Nature* 339:361-364 (1989)), ICAM-3 (Fawcett et al., *Nature* 360:481-484 (1992); Vezeux et al., *Nature* 360:485-488, (1992); de Fougères and Springer, *J. Exp. Med.* 175:185-190 (1990)) and Telencephalin (Tian et al., *J. Immunol.* 158:928-936 (1997)).

30 The CD11/CD18 family is related structurally and genetically to the larger integrin family of receptors that modulate cell adhesive interactions, which include; embryogenesis, adhesion to extracellular substrates, and cell differentiation (Hynes, R. O., *Cell* 48:549-554 (1987); Kishimoto et al., *Adv. Immunol.* 46:149-182 (1989); Kishimoto et al., *Cell* 48:681-690 (1987); Ruoslahti et al., *Science* 238:491-497 (1987).

35 Integrins are a class of membrane-spanning heterodimers comprising an  $\alpha$  subunit in noncovalent association with a  $\beta$  subunit. The  $\beta$  subunits are generally capable of association with more than one  $\alpha$  subunit and the heterodimers sharing a common  $\beta$  subunit have been classified as

subfamilies within the integrin population (Larson and Springer, "Structure and function of leukocyte integrins," *Immunol. Rev.* 114:181-217 (1990)).

The integrin molecules of the CD11/CD18 family, and their cellular ligands, have been found to mediate a variety of cell-cell interactions, especially in inflammation. These proteins have been demonstrated to be critical for adhesive functions in the immune system (Kishimoto *et al.*, *Adv. Immunol.* 46:149-182 (1989)). Monoclonal antibodies to LFA-1 have been shown to block leukocyte adhesion to endothelial cells (Dustin *et al.*, *J. Cell. Biol.* 107:321-331 (1988); Smith *et al.*, *J. Clin. Invest.* 83:2008-2017 (1989)) and to inhibit T-cell activation (Kuypers *et al.*, *Res. Immunol.* 140:461 (1989)), conjugate formation required for antigen-specific CTL killing (Kishimoto *et al.*, *Adv. Immunol.* 46:149-182 (1989)), T. cell proliferation (Davignon *et al.*, *J. Immunol.* 127:590-595 (1981)) and NK cell killing (Krensky *et al.*, *J. Immunol.* 131:611-616 (1983)).

#### ICAMs

ICAM-1 (CD54) is a cell surface adhesion receptor that is a member of the immunoglobulin protein super-family (Rothlein *et al.*, *J. Immunol.* 137:1270-1274 (1986); Staunton *et al.*, *Cell* 52:925-933 (1988)). Members of this superfamily are characterized by the presence of one or more Ig homology regions, each consisting of a disulfide-bridged loop that has a number of anti-parallel  $\beta$ -pleated strands arranged in two sheets. Three types of homology regions have been identified, each with a typical length and having a consensus sequence of amino acid residues located between the cysteines of the disulfide bond (Williams, A. F. *et al.* *Ann Rev. Immunol.* 6:381-405 (1988); Hunkapillar, T. *et al.* *Adv. Immunol.* 44:1-63 (1989)). ICAM-1 is expressed on a variety of hematopoietic and non-hematopoietic cells and is upregulated at sites of inflammation by a variety of inflammatory mediators (Dustin *et al.*, *J. Immunol.* 137:256-254 (1986)). ICAM-1 is a 90,000-110,000  $M_r$  glycoprotein with a low messenger RNA levels and moderate surface expression on unstimulated endothelial cells. LPS, IL-1 and TNF strongly upregulate ICAM-1 mRNA and surface expression with peak expression at approximately 18-24 hours (Dustin *et al.*, *J. Cell. Biol.* 107:321-331 (1988); Staunton *et al.*, *Cell* 52:925-933 (1988)). ICAM-1 has five extracellular Ig like domains (designated Domains 1, 2, 3, 4 and 5 or D1, D2, D3, D4 and D5) and an intracellular or cytoplasmic domain. The structures and sequence of the domains is described by Staunton *et al.* (*Cell* 52:925-933 (1988)).

ICAM-1 was defined originally as a counter-receptor for LFA-1 (Springer *et al.*, *Ann. Rev. Immunol.* 5:223-252 (1987); Marlin *Cell* 51:813-819 (1987); Simmons *et al.*, *Nature* 331:624-627 (1988); Staunton *Nature* 339:61-64 (1989); Staunton *et al.*, *Cell* 52:925-933 (1988)). The LFA-1/ICAM-1 interaction is known to be at least partially responsible for lymphocyte adhesion (Dustin *et al.*, *J. Cell. Biol.* 107:321-331 (1988); Mentzer *et al.*, *J. Cell. Physiol.* 126:285-290 (1986)), monocyte adhesion (Amaout *et al.*, *J. Cell Physiol.* 137:305 (1988); Mentzer *et al.*, *J. Cell. Physiol.* 130:410-415 (1987); te Velde *et al.*, *Immunology* 61:261-267 (1987)), and neutrophil adhesion (Loet *et al.*, *J. Immunol.* 143(10):3325-3329 (1989); Smith *et al.*, *J. Clin. Invest.* 83:2008-2017 (1989)) to endothelial cells. Through the development of function blocking monoclonal antibodies to ICAM-1 additional ligands for LFA-

1 were identified, ICAM-2 and ICAM-3 (Simmons, *Cancer Surveys* 24, Cell Adhesion and Cancer, 1995) that mediate the adhesion of lymphocytes to other leukocytes as well as non-hematopoietic cells. Interactions of LFA-1 with ICAM-2 are thought to mediate natural killer cell activity (Helander *et al.*, *Nature* 382:265-267 (1996)) and ICAM-3 binding is thought to play a role in  
5 lymphocyte activation and the initiation of the immune response (Simmons, *ibid*). The precise role of these ligands in normal and aberrant immune responses remains to be defined.

#### Disorders Mediated by T Lymphocytes

Function blocking monoclonal antibodies have shown that LFA-1 is important in T-lymphocyte-mediated killing, T-helper lymphocyte responses, natural killing, and antibody-dependent killing (Springer *et al.*, *Ann. Rev. Immunol* 5:223-252 (1987)). Adhesion to the target cell  
10 as well as activation and signaling are steps that are blocked by antibodies against LFA-1.

Many disorders and diseases are mediated through T lymphocytes and treatment of these diseases have been addressed through many routes. Rheumatoid arthritis (RA) is one such disorder. Current therapy for RA includes bed rest, application of heat, and drugs. Salicylate is  
15 the currently preferred treatment drug, particularly as other alternatives such as immunosuppressive agents and adrenocorticosteroids can cause greater morbidity than the underlying disease itself. Nonsteroidal anti-inflammatory drugs are available, and many of them have effective analgesic, anti-pyretic and anti-inflammatory activity in RA patients. These include cyclosporin, indomethacin, phenylbutazone, phenylacetic acid derivatives such as ibuprofen and  
20 fenoprofen, naphthalene acetic acids (naproxen), pyrrolealkanoic acid (tometin), indoleacetic acids (sulindac), halogenated anthranilic acid (meclofenamate sodium), piroxicam, and diflunisal. Other drugs for use in RA include anti-malarials such as chloroquine, gold salts and penicillamine. These alternatives frequently produce severe side effects, including retinal lesions and kidney and bone marrow toxicity. Immunosuppressive agents such as methotrexate have been used only in the  
25 treatment of severe and unremitting RA because of their toxicity. Corticosteroids also are responsible for undesirable side effects (e.g., cataracts, osteoporosis, and Cushing's disease syndrome) and are not well tolerated in many RA patients.

Another disorder mediated by T lymphocytes is host rejection of grafts after transplantation. Attempts to prolong the survival of transplanted allografts and xenografts, or to  
30 prevent host versus graft rejection, both in experimental models and in medical practice, have centered mainly on the suppression of the immune apparatus of the host/recipient. This treatment has as its aim preventive immunosuppression and/or treatment of graft rejection. Examples of agents used for preventive immunosuppression include cytotoxic drugs, anti-metabolites, corticosteroids, and anti-lymphocytic serum. Nonspecific immunosuppressive agents found  
35 particularly effective in preventive immunosuppression (azathioprine, bromocryptine, methylprednisolone, prednisone, and most recently, cyclosporin A) have significantly improved the clinical success of transplantation. The nephrotoxicity of cyclosporin A after renal transplantation has been reduced by co-administration of steroids such as prednisolone, or

prednisolone in conjunction with azathioprine. In addition, kidneys have been grafted successfully using anti-lymphocyte globulin followed by cyclosporin A. Another protocol being evaluated is total lymphoid irradiation of the recipient prior to transplantation followed by minimal immunosuppression after transplantation.

5 Treatment of rejection has involved use of steroids, 2-amino-6-aryl-5-substituted pyrimidines, heterologous anti-lymphocyte globulin, and monoclonal antibodies to various leukocyte populations, including OKT-3. See generally *J. Pediatrics*, 111: 1004-1007 (1987), and specifically U.S. Pat. No. 4,665,077.

10 The principal complication of immunosuppressive drugs is infections. Additionally, systemic immunosuppression is accompanied by undesirable toxic effects (e.g., nephrotoxicity when cyclosporin A is used after renal transplantation) and reduction in the level of the hemopoietic stem cells. Immunosuppressive drugs may also lead to obesity, poor wound healing, steroid hyperglycemia, steroid psychosis, leukopenia, gastrointestinal bleeding, lymphoma, and hypertension.

15 In view of these complications, transplantation immunologists have sought methods for suppressing immune responsiveness in an antigen-specific manner (so that only the response to the donor alloantigen would be lost). In addition, physicians specializing in autoimmune disease strive for methods to suppress autoimmune responsiveness so that only the response to the self-antigen is lost. Such specific immunosuppression generally has been achieved by modifying either  
20 the antigenicity of the tissue to be grafted or the specific cells capable of mediating rejection. In certain instances, whether immunity or tolerance will be induced depends on the manner in which the antigen is presented to the immune system. Pretreating the allograft tissues by growth in tissue culture before transplantation has been found in two murine model systems to lead to permanent acceptance across MHC barriers. Lafferty *et al.*, *Transplantation*, 22:138-149 (1976);  
25 Bowen *et al.*, *Lancet*, 2:585-586 (1979). It has been hypothesized that such treatment results in the depletion of passenger lymphoid cells and thus the absence of a stimulator cell population necessary for tissue immunogenicity. Lafferty *et al.*, *Annu. Rev. Immunol.*, 1:143 (1983). See also Lafferty *et al.*, *Science*, 188:259-261 (1975) (thyroid held in organ culture), and Gores *et al.*, *J. Immunol.*, 137:1482-1485 (1986) and Faustman *et al.*, *Proc. Natl. Acad. Sci. U.S.A.*, 78: 5156-5159  
30 (1981) (islet cells treated with murine anti-Ia antisera and complement before transplantation). Also, thyroids taken from donor animals pretreated with lymphocytotoxic drugs and gamma radiation and cultured for ten days *in vitro* were not rejected by any normal allogeneic recipient (Gose and Bach, *J.Exp.Med.*, 149:1254-1259 (1979)). All of these techniques involve depletion or removal of donor lymphocyte cells.

35 In some models such as vascular and kidney grafts, there exists a correlation between Class II matching and prolonged allograft survival, a correlation not present in skin grafts (Pescovitz *et al.*, *J.Exp.Med.*, 160:1495-1508 (1984); Conti *et al.*, *Transplant. Proc.*, 19: 652-654 (1987)). Therefore, donor-recipient HLA matching has been utilized. Additionally, blood transfusions

prior to transplantation have been found to be effective (Opelz *et al.*, *Transplant. Proc.*, 4: 253 (1973); Persijn *et al.*, *Transplant. Proc.*, 23:396 (1979)). The combination of blood transfusion before transplantation, donor-recipient HLA matching, and immunosuppression therapy (cyclosporin A) after transplantation was found to improve significantly the rate of graft survival, and the effects were found to be additive (Opelz *et al.*, *Transplant. Proc.*, 17:2179 (1985)).

The transplantation response may also be modified by antibodies directed at immune receptors for MHC antigens (Bluestone *et al.*, *Immunol. Rev.* 90:5-27 (1986)). Further, graft survival can be prolonged in the presence of antigraft antibodies, which lead to a host reaction that in turn produces specific immunosuppression (Lancaster *et al.*, *Nature*, 315: 336-337 (1985)). The immune response of the host to MHC antigens may be modified specifically by using bone marrow transplantation as a preparative procedure for organ grafting. Thus, anti-T-cell monoclonal antibodies are used to deplete mature T-cells from the donor marrow inoculum to allow bone marrow transplantation without incurring graft-versus-host disease (Mueller-Ruchholtz *et al.*, *Transplant Proc.*, 8:537-541 (1976)). In addition, elements of the host's lymphoid cells that remain for bone marrow transplantation solve the problem of immunoincompetence occurring when fully allogeneic transplants are used.

As shown in Fig. 1, lymphocyte adherence to endothelium is a key event in the process of inflammation. There are at least three known pathways of lymphocyte adherence to endothelium, depending on the activation state of the T-cell and the endothelial cell. T-cell immune recognition requires the contribution of the T-cell receptor as well as adhesion receptors, which promote attachment of T-cells to antigen-presenting cells and transduce regulatory signals for T-cell activation. The lymphocyte function associated (LFA) antigen-1 (LFA-1, CD11a/CD18,  $\alpha_L\beta_2$ : where  $\alpha_L$  is CD11a and  $\beta_2$  is CD18) has been identified as the major integrin receptor on lymphocytes involved in these cell adherence interactions leading to several pathological states. ICAM-1, the endothelial cell immunoglobulin-like adhesion molecule, is a known ligand for LFA-1 and is implicated directly in graft rejection, psoriasis, and arthritis.

LFA-1 is required for a range of leukocyte functions, including lymphokine production of helper T-cells in response to antigen-presenting cells, killer T-cell-mediated target cell lysis, and immunoglobulin production through T-cell/B-cell interactions. Activation of antigen receptors on T-cells and B-cells allows LFA-1 to bind its ligand with higher affinity.

Monoclonal antibodies (MAbs) directed against LFA-1 led to the initial identification and investigation of the function of LFA-1 (Davignon *et al.*, *J. Immunol.*, 127:590 (1981)). LFA-1 is present only on leukocytes (Krensky *et al.*, *J. Immunol.*, 131:611 (1983)), and ICAM-1 is distributed on activated leukocytes, dermal fibroblasts, and endothelium (Dustin *et al.*, *J. Immunol.* 137:245 (1986)).

Previous studies have investigated the effects of anti-CD11a MAbs on many T-cell-dependent immune functions *in vitro* and a limited number of immune responses *in vivo*. *In vitro*, anti-CD11a MAbs inhibit T-cell activation (Kuypers *et al.*, *Res. Immunol.*, 140:461 (1989)), T-cell-



dependent B-cell proliferation and differentiation (Davignon *et al.*, *supra*; Fischer *et al.*, *J. Immunol.*, 136:3198 (1986)), target cell lysis by cytotoxic T-lymphocytes (Krensky *et al.*, *supra*), formation of immune conjugates (Sanders *et al.*, *J. Immunol.*, 137:2395 (1986); Mentzer *et al.*, *J. Immunol.*, 135:9 (1985)), and the adhesion of T-cells to vascular endothelium (Lo *et al.*, *J. Immunol.*, 143:3325 (1989)).

5 Also, the antibody 5C6 directed against CD11b/CD18 was found to prevent intra-islet infiltration by both macrophages and T cells and to inhibit development of insulin-dependent diabetes mellitus in mice (Hutchings *et al.*, *Nature*, 348: 639 (1990)).

The observation that LFA-1:ICAM-1 interaction is necessary to optimize T-cell function *in vitro*, and that anti-CD11a MAbs induce tolerance to protein antigens (Benjamin *et al.*, *Eur. J. Immunol.*, 18:1079 (1988)) and prolongs tumor graft survival in mice (Heagy *et al.*, *Transplantation*, 37: 520-523 (1984)) was the basis for testing the MAbs to these molecules for prevention of graft rejection in humans.

Experiments have also been carried out in primates. For example, based on experiments in monkeys it has been suggested that a MAb directed against ICAM-1 can prevent or even reverse kidney graft rejection (Cosimi *et al.*, "Immunosuppression of Cynomolgus Recipients of Renal Allografts by R6.5, a Monoclonal Antibody to Inter cellular Adhesion Molecule-1," in Springer *et al.* (eds.), *Leukocyte Adhesion Molecules* New York: Springer, (1988), p. 274; Cosimi *et al.*, *J. Immunology*, 144:4604-4612 (1990)). Furthermore, the *in vivo* administration of anti-CD11a MAb to cynomolgus monkeys prolonged skin allograft survival (Berlin *et al.*, *Transplantation*, 53: 840-849 (1992)).

20 The first successful use of a rat anti-murine CD11a antibody (25-3; IgG1) in children with inherited disease to prevent the rejection of bone-marrow-mismatched haploidentical grafts was reported by Fischer *et al.*, *Lancet*, 2: 1058 (1986). Minimal side effects were observed. See also Fischer *et al.*, *Blood*, 77: 249 (1991); van Dijken *et al.*, *Transplantation*, 49:882 (1990); and Perez *et al.*, *Bone Marrow Transplantation*, 4:379 (1989). Furthermore, the antibody 25-3 was effective in controlling steroid-resistant acute graft-versus-host disease in humans (Stoppa *et al.*, *Transplant. Int.*, 4:3-7 (1991)).

However, these results were not reproducible in leukemic adult grafting with this MAb (Maraninchi *et al.*, *Bone Marrow Transplant*, 4:147-150 (1989)), or with an anti-CD18 MAb, directed against the invariant chain of LFA-1, in another pilot study (Baume *et al.*, *Transplantation*, 47: 472 (1989)). Furthermore, a rat anti-murine CD11a MAb, 25-3, was unable to control the course of acute rejection in human kidney transplantation (LeMauff *et al.*, *Transplantation*, 52: 291 (1991)).

A review of the use of monoclonal antibodies in human transplantation is provided by Dantal and Souillou, *Current Opinion in Immunology*, 3:740-747 (1991).

35 An earlier report showed that brief treatment with either anti-LFA-1 or anti-ICAM-1 MAbs minimally prolonged the survival of primarily vascularized heterotopic heart allografts in mice (Isobe *et al.*, *Science*, 255:1125 (1992)). However, combined treatment with both MAbs was required to achieve long-term graft survival in this model.

Independently, it was shown that treatment with anti-LFA-1 MAb alone potently and effectively prolongs the survival of heterotopic (ear-pinnae) nonprimarily vascularized mouse heart grafts using a maximum dose of 4 mg/kg/day and treatment once a week after a daily dose (Nakakura *et al.*, *J. Heart Lung Transplant.*, 11:223 (1992)). Nonprimarily vascularized heart allografts are more immunogenic and more resistant to prolongation of survival by MAbs than primarily vascularized heart allografts (Warren *et al.*, *Transplant. Proc.*, 5:717 (1973); Trager *et al.*, *Transplantation*, 47:587 (1989)). The latter reference discusses treatment with L3T4 antibodies using a high initial dose and a lower subsequent dose.

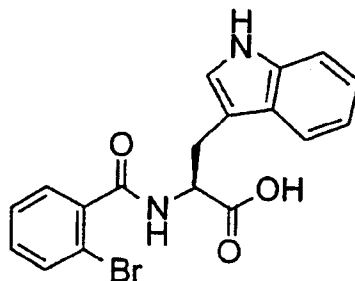
Another study on treating a sclerosis-type disease in rodents using similar antibodies to those used by Nakakura *et al.*, *supra*, is reported by Yednock *et al.*, *Nature*, 356:63-66 (1992).

Additional disclosures on the use of anti-LFA-1 antibodies and ICAM-1, ICAM-2, and ICAM-3 and their antibodies to treat LFA-1-mediated disorders include WO 91/18011 published 11/28/91, WO 91/16928 published 11/14/91, WO 91/16927 published 11/14/91, Can. Pat. Appln. 2,008,368 published 6/13/91, WO 90/03400, WO 90/15076 published 12/13/90, WO 90/10652 published 9/20/90, EP 387,668 published 9/19/90, WO 90/08187 published 7/26/90, WO 90/13281, WO 90/13316, WO 90/13281, WO 93/06864, WO 93/21953, WO 93/13210, WO 94/11400, EP 379,904 published 8/1/90, EP 346,078 published 12/13/89, U.S. Pat. No. 5,002,869, U.S. Pat. No. 5,071,964, U.S. Pat. No. 5,209,928, U.S. Pat. No. 5,223,396, U.S. Pat. No. 5,235,049, U.S. Pat. No. 5,284,931, U.S. Pat. No. 5,288,854, U.S. Pat. No. 5,354,659, Australian Pat. Appln. 15518/88 published 11/10/88, EP 289,949 published 11/9/88, and EP 303,692 published 2/22/89, EP 365,837, EP 314,863, EP 319,815, EP 468, 257, EP 362,526, EP 362, 531, EP 438,310.

Other disclosures on the use of LFA-1 and ICAM peptide fragments and antagonists include; U.S. Pat. No. 5,149,780, U.S. Pat. No. 5,288,854, U.S. Pat. No. 5,340,800, U.S. Pat. No. 5,424,399, U.S. Pat. No. 5,470,953, WO 90/03400, WO 90/13316, WO 90/10652, WO 91/19511, WO 92/03473, WO 94/11400, WO 95/28170, JP 4193895, EP 314,863, EP 362,526 and EP 362,531.

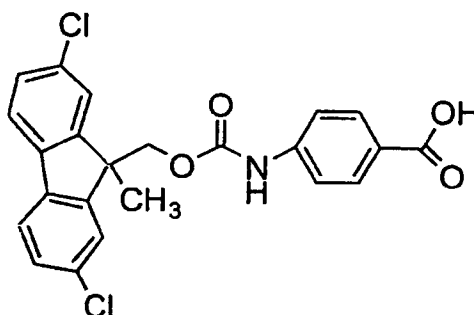
The above methods successfully utilizing anti-LFA-1 or anti-ICAM-1 antibodies, LFA-1 or ICAM-1 peptides, fragments or peptide antagonists represent an improvement over traditional immunosuppressive drug therapy. These studies demonstrate that LFA-1 and ICAM-1 are appropriate targets for antagonism. There is a need in the art to better treat disorders that are mediated by LFA-1 including autoimmune diseases, graft vs. host or host vs. graft rejection, and T-cell inflammatory responses, so as to minimize side effects and sustain specific tolerance to self- or xenoantigens. There is also a need in the art to provide a non-peptide or peptidomimetic antagonist to the LFA-1: ICAM-1 interaction.

At least one peptidomimetic antagonist of the LFA-1:ICAM-1 interaction has shown promise in various *in vitro* assays.



2-Bromobenzoyltryptophan exhibits  $IC_{50}$ 's of about  $2\mu M$  and  $10\mu M$  respectively in human LFA-1:ICAM-1 receptor binding and human T-cell adhesion assays described herein.

5 Recently, aminobenzoic acid derivatives of fluorene have been described in U.S. Patent 5,472,973 is useful anti-inflammatory agents. A representative compound is:



#### Objects of the Invention

Accordingly, it is an object of this invention to provide compositions and therapeutic methods for modulating adhesion between intracellular adhesion molecules (e.g. ICAM-1, -2 and -3) and the leukocyte integrin family of receptors.

It is an object to antagonize CD11/CD18 receptors associated with leukocytes, especially Mac-1 and LFA-1-mediated disorders with minimal side effects.

15 It is an object to control inappropriate inflammatory responses and prevent damage to healthy tissue.

More specifically, it is an object to treat LFA-1-mediated disorders including: psoriasis; responses associated with inflammatory bowel disease (such as Crohn's disease and ulcerative colitis), dermatitis, meningitis, encephalitis, uveitis, allergic conditions such as eczema and asthma, conditions involving infiltration of T-cells and chronic inflammatory responses, skin hypersensitivity reactions (including poison ivy and poison oak); atherosclerosis, autoimmune diseases such as rheumatoid arthritis, systemic lupus erythematosus (SLE), diabetes mellitus, multiple sclerosis, Reynaud's syndrome, autoimmune thyroiditis, experimental autoimmune encephalomyelitis, Sjorgen's syndrome, juvenile onset diabetes, and immune responses associated with delayed hypersensitivity mediated by cytokines and T-lymphocytes typically found in

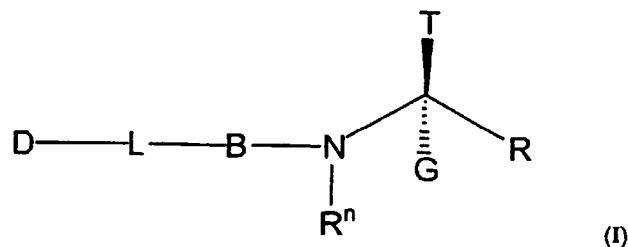
tuberculosis, sarcoidosis, polymyositis, granulomatosis and vasculitis; pernicious anemia; diseases involving leukocyte diapedesis; CNS inflammatory disorder, multiple organ injury syndrome secondary to septicaemia or trauma; autoimmune hemolytic anemia; myasthenia gravis; antigen-antibody complex mediated diseases; all types of transplantations, including graft vs. host or host vs. graft disease, HIV and rhinovirus infection, pulmonary fibrosis, and the like.

These and other objects will become apparent to one of ordinary skill in the art.

#### Summary of the Invention

These objects are accomplished by providing a method and antagonist compositions for modulating adhesion between intracellular adhesion molecules (e.g. ICAM-1, -2 and -3) and the leukocyte integrin family of receptors. The method and antagonists are especially useful for treating CD11/CD18, especially Mac-1 and LFA-1-mediated disorders in a mammal, especially a human, comprising administering to the mammal a therapeutically effective amount of the antagonist. Suitable leukocyte integrin antagonists, especially Mac-1 and LFA-1 antagonists of this invention are represented by Structural Formula I below. Preferably, the LFA-1 antagonist is a specific antagonist of the leukocyte integrin CD11a( $\alpha_L$ )/CD18( $\beta_2$ ). Such antagonists are especially useful to treat chronic LFA-1 mediated disorders. Preferably, these LFA-1 antagonists are used to treat psoriasis, alopecia, organ transplant, inflammatory bowel disease (IBD), rheumatoid arthritis (RA), systemic lupus erythematosus (SLE), type-1 diabetes, multiple sclerosis (MS), asthma, graft versus host (GVH) disease, scleredoma, endometriosis and vitiligo. Optionally, certain compounds embraced by Formula I are also capable of antagonizing Mac-1 CD11b( $\alpha_M$ )/CD18( $\beta_2$ ) binding to ICAM-1 and additional ligands including iC3b, fibrinogen and Factor X. These compounds are therefore useful for inhibiting adhesion of neutrophils and leukocytes expressing both or either LFA-1 and Mac-1 in both chronic and acute leukocyte/neutrophil mediated disorders. More specifically these disorders include; ischemic reperfusion injury mediated by neutrophils such as acute myocardial infarction, restenosis following PTCA, invasive procedures such as cardiopulmonary bypass surgery, cerebral edema, stroke, traumatic brain injury, multiple sclerosis, systemic lupus erythematosus, hemorrhagic shock, burns, ischemic kidney disease, multi-organ failure, wound healing and scar formation, atherosclerosis as well as organ failure post-transplant.

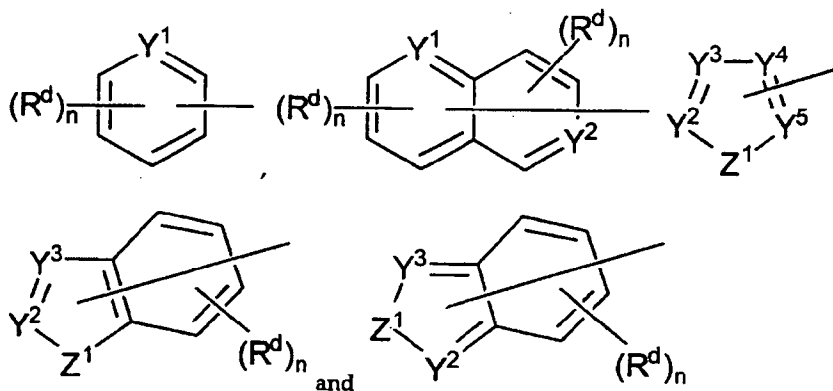
The antagonist is represented by formula I



Where D is a mono-, bi-, or tricyclic saturated, unsaturated, or aromatic ring, each ring

having 5-, 6- or 7 atoms in the ring where the atoms in the ring are carbon or from 1-4 heteroatoms selected from; nitrogen, oxygen, and sulfur, where any sulfur ring atom may optionally be oxidized and any carbon ring atom may form a double bond with O,  $\text{NR}^n$  and  $\text{CR}^1\text{R}^{1'}$ , each ring nitrogen substituted with  $\text{R}^n$  and any ring carbon substituted with  $\text{R}^d$ .

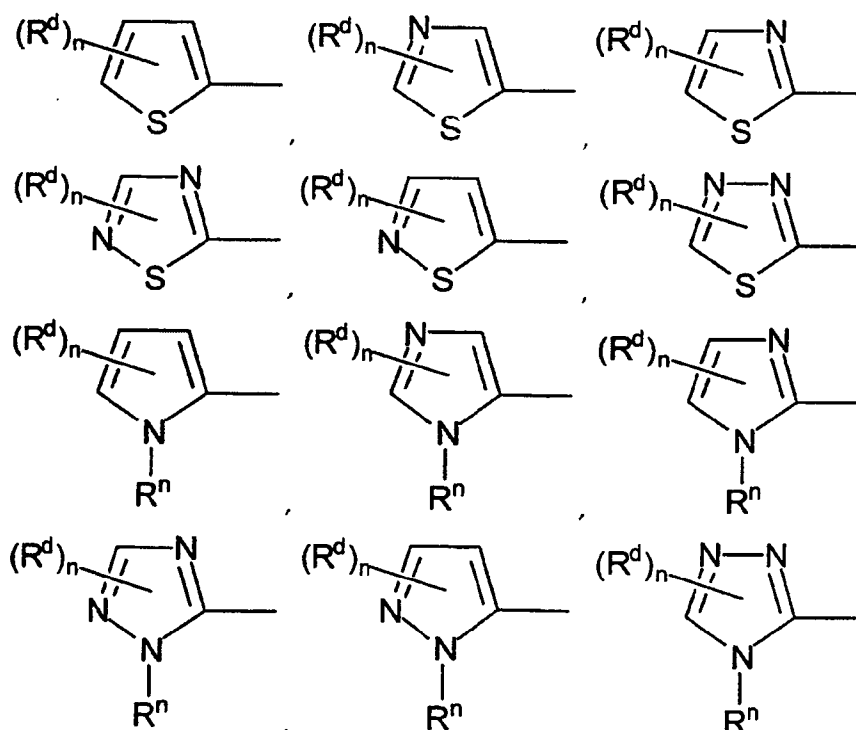
- 5 Optionally, D is an aromatic homocycle or aromatic heterocycle containing 1-3 heteroatoms selected from the group N, S and O, the homo- or hetero-cycles selected from:



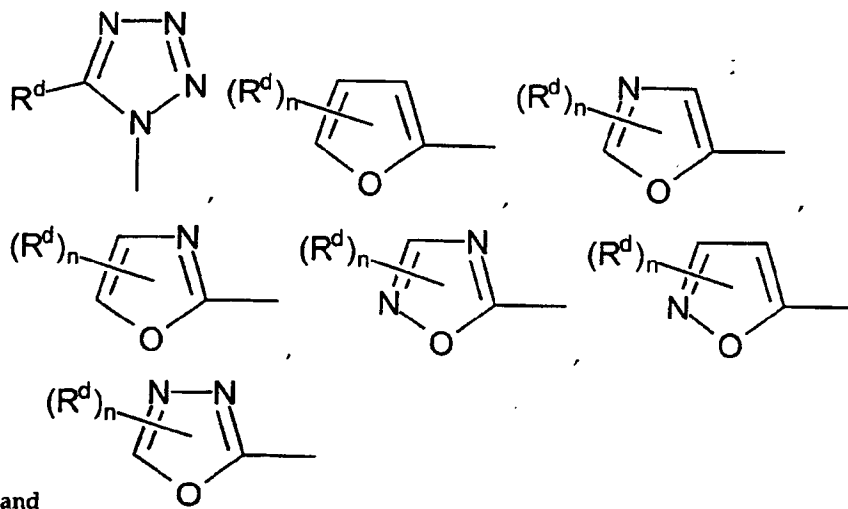
where  $\text{Y}^1, \text{Y}^2, \text{Y}^3, \text{Y}^4$  and  $\text{Y}^5$  are CH,  $\text{CR}^d$  or N,  $\text{Z}^1$  is O, S, NH or  $\text{NR}^n$  and n is 0-3.

- 10 More specifically, D may be:

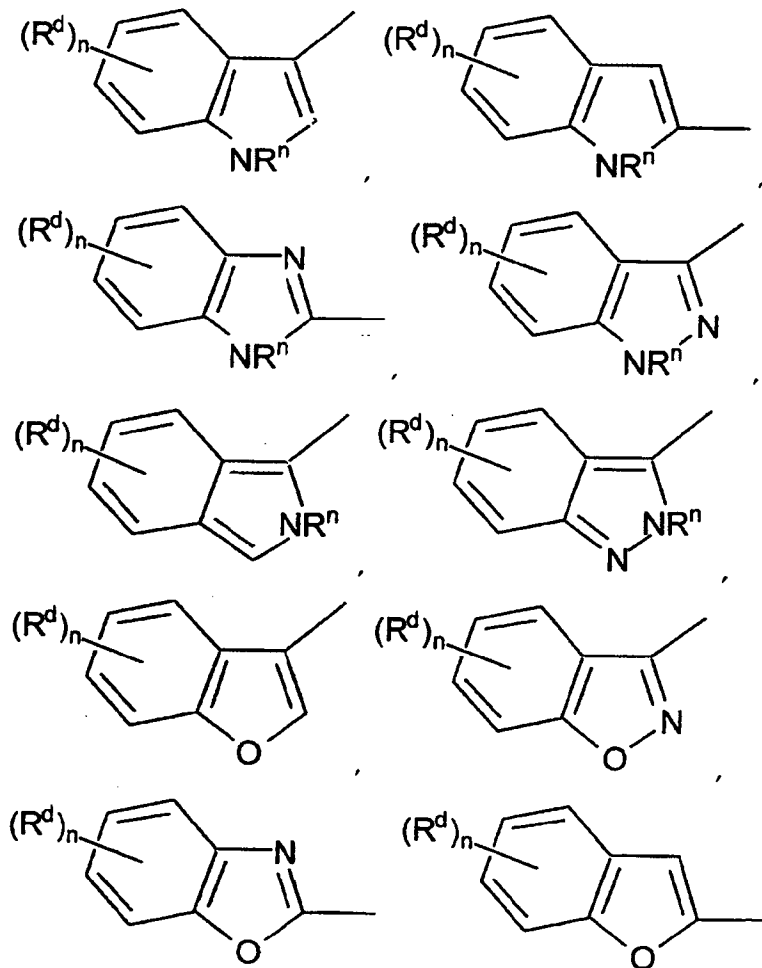
1) a 5-member aromatic heterocycle or het selected from:



15

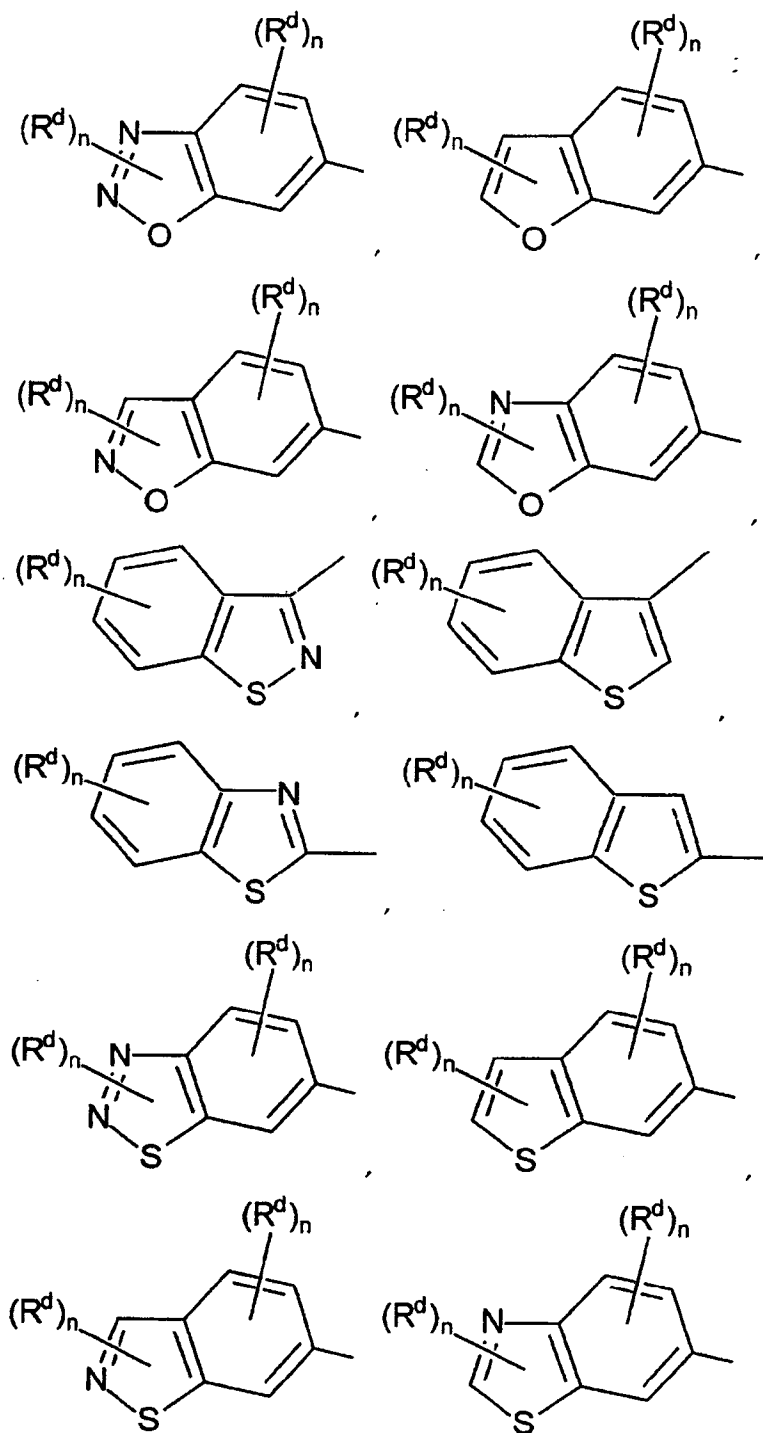


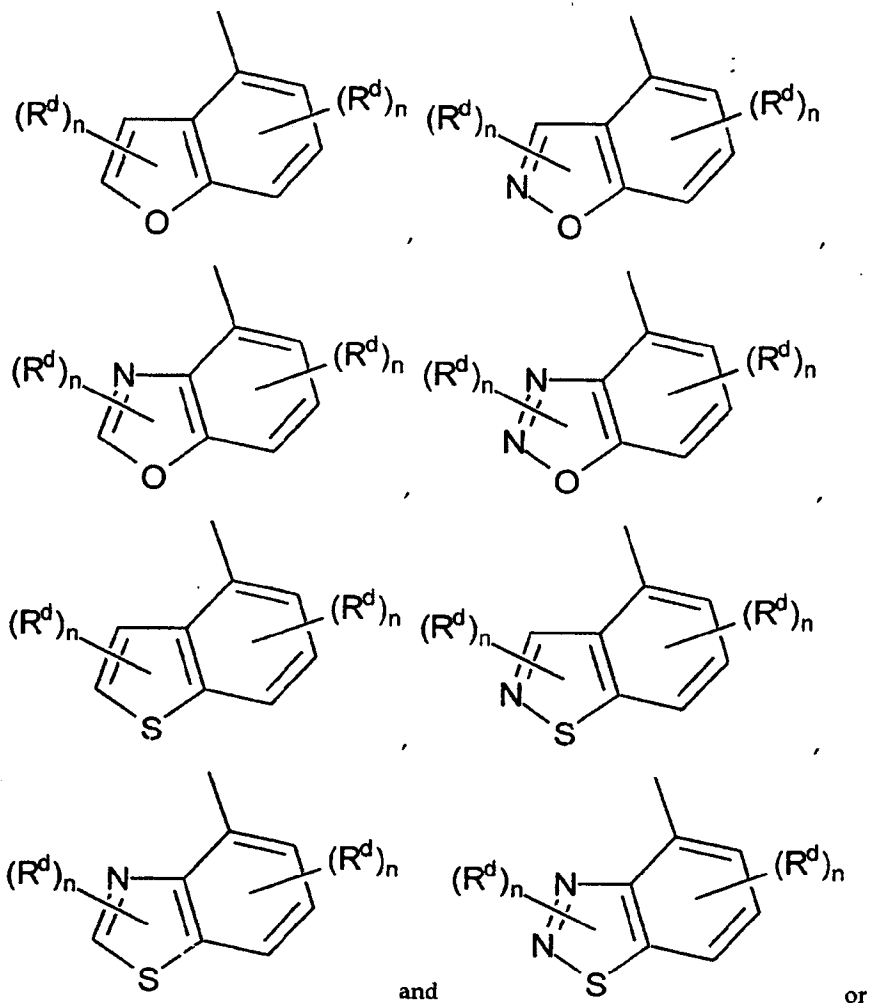
5 2) a 9-member aromatic heterobicyclic selected from;



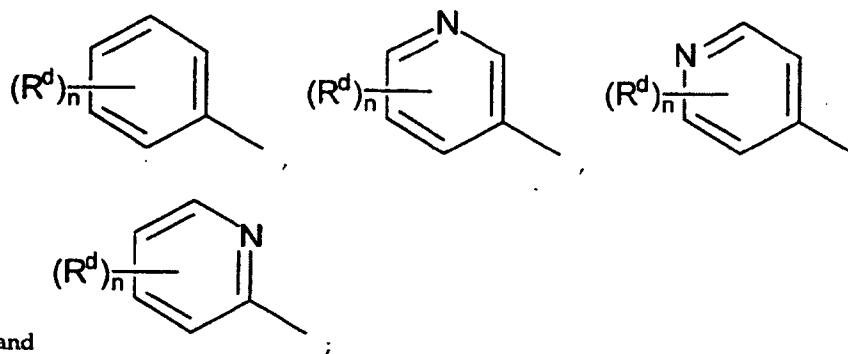
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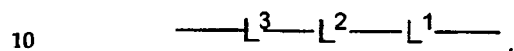




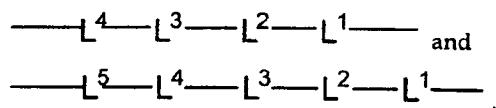
5 3) a 6-member aromatic hetero- or homocycle selected from;



L is a bivalent linking group selected from







where:

$L^1$  may be oxo (O), S(O)<sub>s</sub>, C(=O), C(=N-R<sup>n</sup>), C(=CR<sup>1</sup>R<sup>1'</sup>), C(R<sup>1</sup>R<sup>1'</sup>), C(R<sup>1</sup>), C, het, N(R<sup>n</sup>) or

5 N;

$L^2$  may be oxo (O), S(O)<sub>s</sub>, C(=O), C(=N-O-R<sup>0</sup>), C(=CR<sup>2</sup>R<sup>2'</sup>), C(R<sup>2</sup>R<sup>2'</sup>), C(R<sup>2</sup>), C, het, N(R<sup>n</sup>)

or N;

$L^3$  may be oxo (O), S(O)<sub>s</sub>, C(=O), C(=N-O-R<sup>0</sup>), C(=CR<sup>3</sup>R<sup>3'</sup>), C(R<sup>3</sup>R<sup>3'</sup>), C(R<sup>3</sup>), C, het, N(R<sup>n</sup>)

or N;

10  $L^4$  is absent or may be oxo (O), S(O)<sub>s</sub>, C(=O), C(=N-O-R<sup>0</sup>), C(=CR<sup>4</sup>R<sup>4'</sup>), C(R<sup>4</sup>R<sup>4'</sup>), C(R<sup>4</sup>), C,

NR<sup>n</sup> or N; and

$L^5$  is absent or may be oxo (O), S(O)<sub>s</sub>, C(=O), C(=N-R<sup>n</sup>), C(R<sup>5</sup>R<sup>5'</sup>), C(=CR<sup>5</sup>R<sup>5'</sup>), C(R<sup>5</sup>), C,

NR<sup>n</sup> or N;

provided that only one of  $L^1$ - $L^3$  may be het and that when one of  $L^1$ - $L^3$

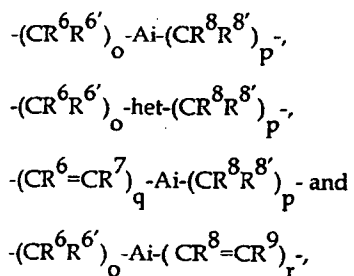
15 is het the other  $L^1$ - $L^5$  may be absent.

$R^1, R^{1'}, R^2, R^{2'}, R^3, R^{3'}, R^4, R^{4'}, R^5$  and  $R^{5'}$  each are independently selected from R<sup>a</sup>, R<sup>c</sup> and U-Q-V-W. Optionally,  $R^2$  and  $R^{2'}$  separately or together may form a saturated, unsaturated or aromatic fused ring with B through a substituent R<sup>p</sup> on B, the fused ring containing 5, 6 or 7 atoms in the ring and optionally containing 1-3 heteroatoms selected from the group O, S and N, where

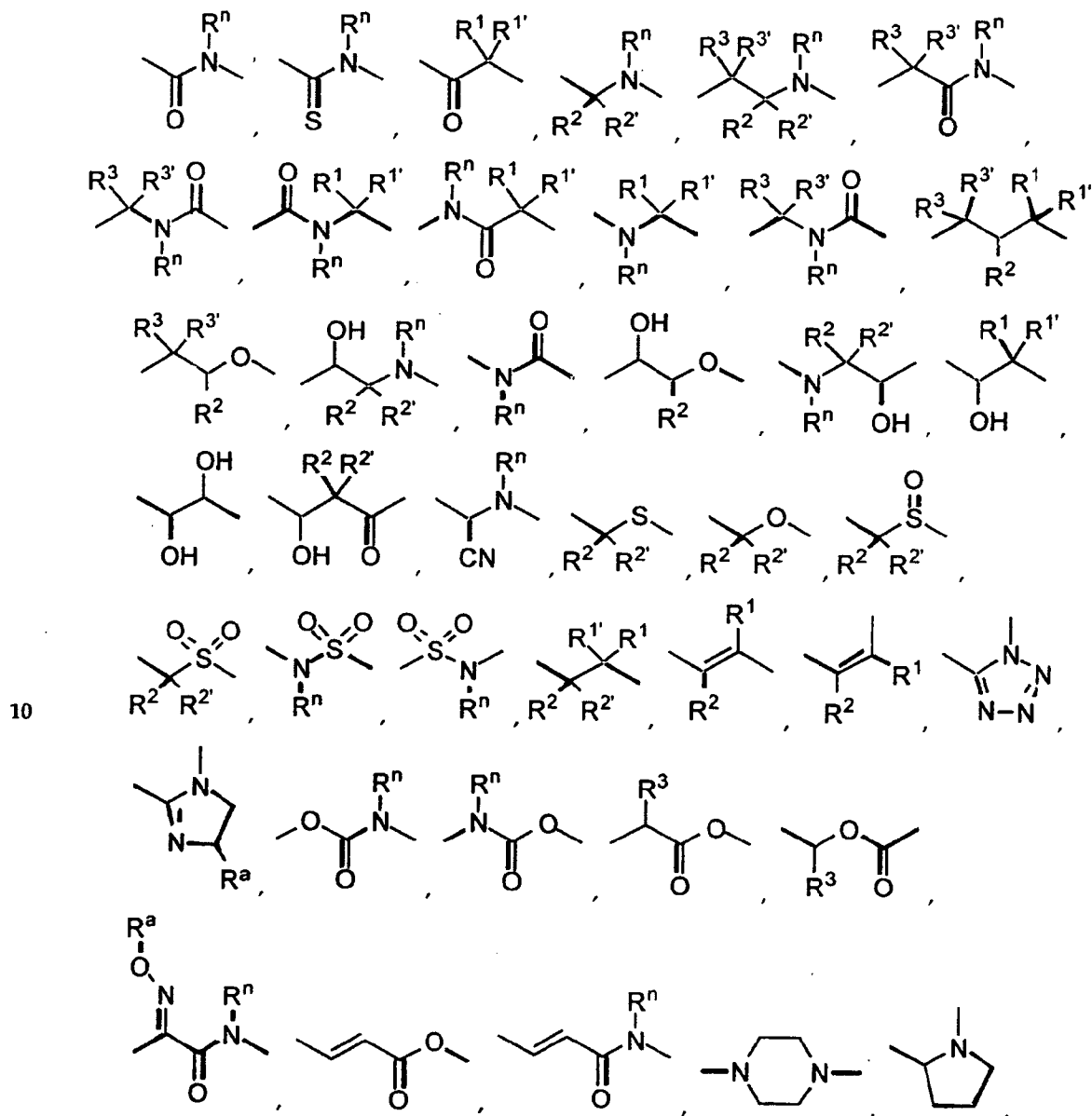
20 any S or N may optionally be oxidized. Optionally,  $R^3$  and  $R^{3'}$  separately or together and  $R^4$  and  $R^{4'}$  separately or together may form a saturated, unsaturated or aromatic fused ring with D through a substituent R<sup>d</sup> on D, the fused ring containing 5, 6 or 7 atoms in the ring and optionally containing 1-3 heteroatoms selected from the group O, S and N, where any S or N may optionally be oxidized.

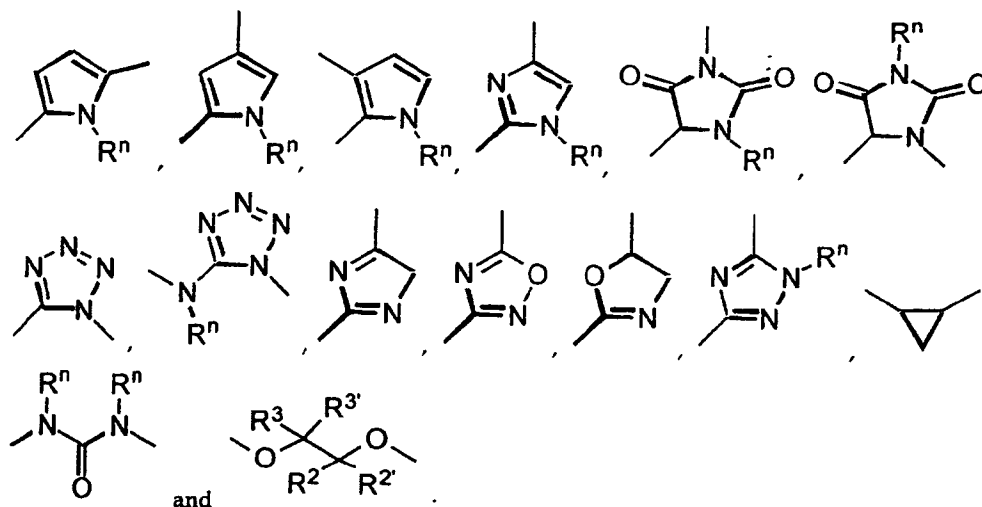
Also optionally, each  $R^1$ - $R^5$ , or NR<sup>n</sup> together with any other  $R^1$ - $R^5$  or NR<sup>n</sup> may form a 5, 6 or 7 member homo- or heterocycle either saturated, unsaturated or aromatic optionally containing 1-3 additional heteroatoms selected from N, O and S, each cycle substituted with 0-3 R<sup>d</sup>, where s is 0-2, and where any carbon or sulfur ring atom may optionally be oxidized.

More specifically, the bivalent linker L may be:



5 where Ai is selected from





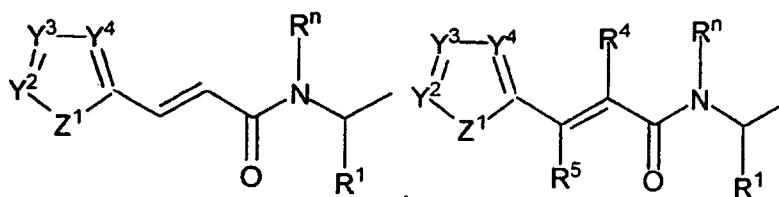
where o is 0-1, p is 0-1, q is 0-1 and r is 0-1.

- 5        het is any mono-, bi-, or tricyclic saturated, unsaturated, or aromatic ring where at least one ring is a 5-, 6- or 7-membered ring containing from one to four heteroatoms selected from the group nitrogen, oxygen, and sulfur, the 5-membered ring having from 0 to 2 double bonds and the 6- or 7-membered ring having from 0 to 3 double bonds and where any carbon or sulfur atoms in the ring may optionally be oxidized, and where any nitrogen heteroatom may optionally be quaternized and
- 10        where any ring may contain from 0-3 R<sup>d</sup>.

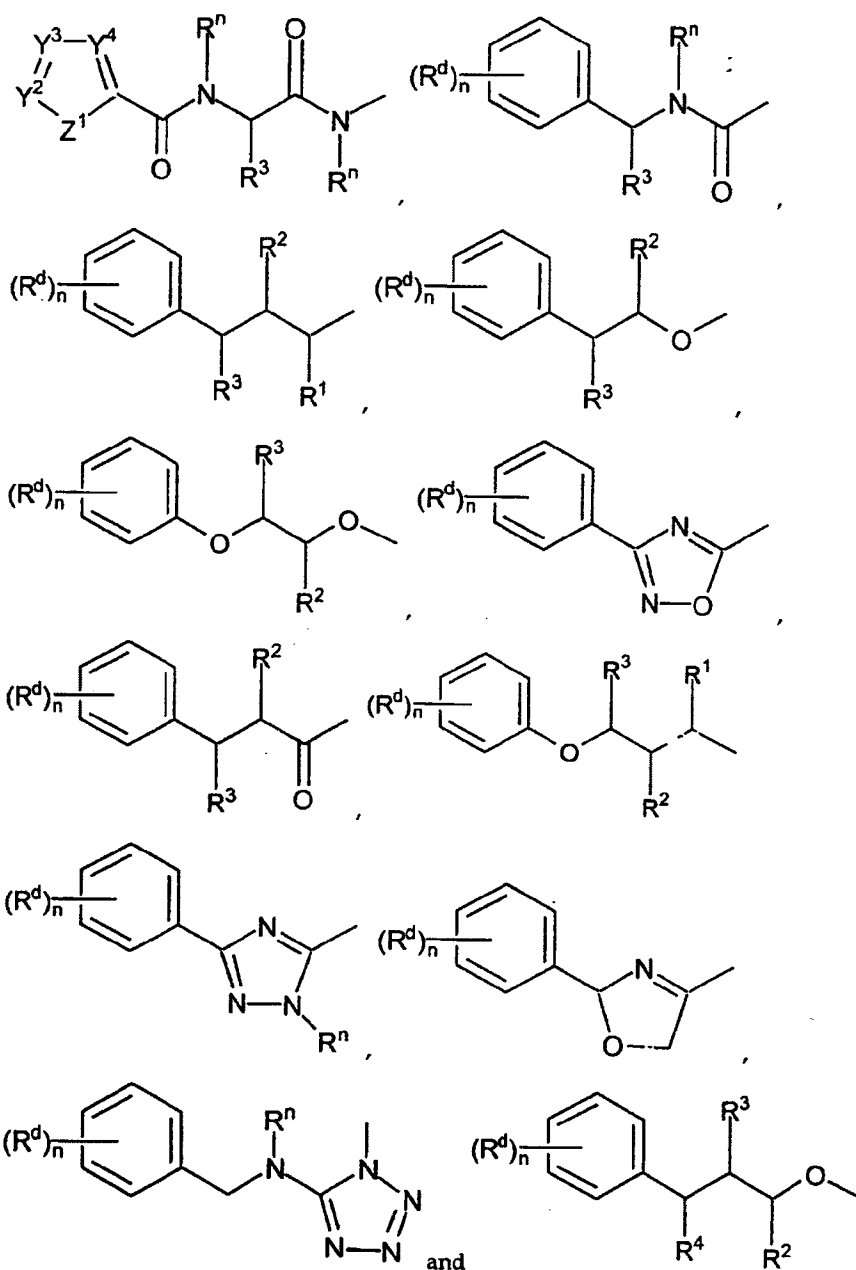
Optionally L is a bivalent linking group selected from the group:

- C<sub>3</sub>-C<sub>5</sub>-alkyl-, -C<sub>3</sub>-C<sub>5</sub>-alkenyl-, -CH<sub>2</sub>C(=O)NH-, -CH<sub>2</sub>NH-C(=O)-, -O-CH<sub>2</sub>-C(=O)-, -CH<sub>2</sub>-CH<sub>2</sub>-C(=O)-, -CH=CH-C(=O)NH-CH<sub>2</sub>-, -CH=CH-C(=O)NH-CH-(CH<sub>3</sub>)-, -CH(OH)-CH<sub>2</sub>-O-, -CH(OH)-CH<sub>2</sub>-N(CH<sub>3</sub>)-, -CH(OH)-CH<sub>2</sub>-CH<sub>2</sub>-, -CH<sub>2</sub>-CH<sub>2</sub>-CH(OH)-, -O-CH<sub>2</sub>-CH(OH)-, -O-CH<sub>2</sub>-CH(OH)-CH<sub>2</sub>-, -O-CH<sub>2</sub>-CH<sub>2</sub>-CH(OH)-, -O-CH<sub>2</sub>-CH<sub>2</sub>-O-, -CH<sub>2</sub>-CH<sub>2</sub>-CH<sub>2</sub>-O-, -CH<sub>2</sub>-CH(OH)-CH<sub>2</sub>-O-, -CH<sub>2</sub>-CH<sub>2</sub>-O-, -CH-(CH<sub>3</sub>)-NH-C(=O)-, -CH<sub>2</sub>-NH-SO<sub>2</sub>-, -NH-SO<sub>2</sub>-CH<sub>2</sub>-, -CH<sub>2</sub>-SO<sub>2</sub>NH-, -SO<sub>2</sub>NH-CH<sub>2</sub>-, -C(=O)-NH-C(=O)-, -NH-C(=O)-NH-, -NH-C(=O)-NH-CH<sub>2</sub>-, -CH<sub>2</sub>-NH-C(=O)-NH-, -C(=O)-NH-CH<sub>2</sub>-C(=O)-NH-, -NH-C(=O)-O- and -O-C(=O)-NH-.
- 15

Optionally, specific D-L combinations are selected from:

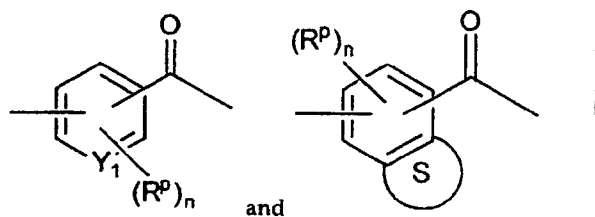


20



5

B is selected from the group



where



is a fused hetero- or homocyclic ring containing 5, 6 or 7 atoms, the ring being unsaturated, partially saturated or aromatic, the heteroatoms selected from 1-3 O, S and N.

$Y_1$  is selected from CH and N and n is 0-3.

- 5 G is selected from hydrogen and  $C_1-C_6$  alkyl, optionally G taken together with T may form a  $C_3-C_6$  cycloalkyl optionally substituted with -V-W.

T is selected from the group 1) a naturally occurring  $\alpha$ -amino-acid side chain or derivatives thereto and U-Q-V-W.

U is an optionally substituted bivalent radical selected from the group;

- 10  $C_1-C_6$  alkyl,  $C_0-C_6$  alkyl-Q,  $C_2-C_6$  alkenyl-Q, and  $C_2-C_6$  alkynyl-Q, where the substituents on any alkyl, alkenyl or alkynyl are 1-3  $R^a$ .

Q is absent or is selected from the group; -O-,  $-S(O)_s$ -,  $-SO_2-N(R^n)$ -,  $-N(R^n)$ -,  $-N(R^n)-C(=O)-$ ,  $-N(R^n)-C(=O)-O$ -,  $-N(R^n)-SO_2$ -,  $-C(=O)-$ ,  $-C(=O)-O$ -, -het-,  $-C(=O)-N(R^n)$ -,  $-PO(OR^c)O$ - and  $-P(O)O$ -, where s is 0-2 and het is a mono- or bicyclic 5, 6, 7, 9 or 10 member heterocyclic ring, each ring containing 1-4 heteroatoms selected from N, O and S, where the heterocyclic ring may be saturated, partially saturated, or aromatic and any N or S being optionally oxidized, the heterocyclic ring being substituted with 0-3  $R^h$ .

- 15 V is absent or is an optionally substituted bivalent group selected from  $C_1-C_6$  alkyl,  $C_3-C_8$  cycloalkyl,  $C_0-C_6$  alkyl- $C_6-C_{10}$  aryl, and  $C_0-C_6$  alkyl-het, where the substituents on any alkyl are 1-3  $R^a$  and the substituents on any aryl or het are 1-3  $R^d$ .

- 20 W is selected from the group; hydrogen,  $-OR^o$ ,  $-SR^m$ ,  $-NR^nR^{n'}$ ,  $-NH-C(=O)-O-R^c$ ,  $-NH-C(=O)-NR^nR^{n'}$ ,  $-NH-C(=O)-R^c$ ,  $-NH-SO_2-R^s$ ,  $-NH-SO_2-NR^nR^{n'}$ ,  $-NH-SO_2-NH-C(=O)-R^c$ ,  $-NH-C(=O)-NH-SO_2-R^s$ ,  $-C(=O)-NH-C(=O)-O-R^c$ ,  $-C(=O)-NH-C(=O)-R^c$ ,  $-C(=O)-NH-C(=O)-NR^nR^{n'}$ ,  $-C(=O)-NH-SO_2-R^s$ ,  $-C(=O)-NH-SO_2-NR^nR^{n'}$ ,  $-C(=S)-NR^nR^{n'}$ ,  $-SO_2-R^s$ ,  $-SO_2-O-R^s$ ,  $-SO_2-NR^nR^{n'}$ ,  $-SO_2-NH-C(=O)-O-R^c$ ,  $-SO_2-NH-C(=O)-NR^nR^{n'}$ ,  $-SO_2-NH-C(=O)-R^c$ ,  $-O-C(=O)-NR^nR^{n'}$ ,  $-O-C(=O)-R^c$ ,  $-O-C(=O)-NH-C(=O)-R^c$ ,  $-O-C(=O)-NH-SO_2-R^s$  and  $-O-SO_2-R^s$ .

R is selected from  $-C(=O)-R^z$ ,  $-C(=O)-H$ ,  $-CH_2(OH)$  and  $-CH_2O-C(=O)-C_1-C_6$  alkyl.

$R^a$  is  $R^{a'}$  or  $R^{a''}$  substituted with 1-3  $R^{a'}$ .

$R^{a'}$  is selected from the group; hydrogen, halo(F, Cl, Br, I), cyano, isocyanate, carboxy, carboxy- $C_1$ - $C_{11}$  alkyl, amino, amino- $C_1$ - $C_8$  alkyl, aminocarbonyl, carboxamido, carbamoyl, carbamoyloxy, formyl, formyloxy, azido, nitro, imidazolyl, ureido, thioureido, thiocyanato, hydroxy,  $C_1$ - $C_6$  alkoxy, mercapto, sulfonamido, het, phenoxy, phenyl, benzamido, tosyl, morpholino, morpholinyl, piperazinyl, piperidinyl, pyrrolinyl, imidazolyl and indolyl.

$R^{a''}$  is selected from the group  $C_0$ - $C_{10}$  alkyl-Q- $C_0$ - $C_6$  alkyl,  $C_0$ - $C_{10}$  alkenyl-Q- $C_0$ - $C_6$  alkyl,  $C_0$ - $C_{10}$  alkynyl-Q- $C_0$ - $C_6$  alkyl,  $C_3$ - $C_{11}$  cycloalkyl-Q- $C_0$ - $C_6$  alkyl,  $C_3$ - $C_{10}$  cycloalkenyl-Q- $C_0$ - $C_6$  alkyl,  $C_1$ - $C_6$  alkyl- $C_6$ - $C_{12}$  aryl-Q- $C_0$ - $C_6$  alkyl,  $C_6$ - $C_{10}$  aryl- $C_1$ - $C_6$  alkyl-Q- $C_0$ - $C_6$  alkyl,  $C_0$ - $C_6$  alkyl-het-Q- $C_0$ - $C_6$  alkyl,  $C_0$ - $C_6$  alkyl-Q-het- $C_0$ - $C_6$  alkyl, het- $C_0$ - $C_6$  alkyl-Q- $C_0$ - $C_6$  alkyl,  $C_0$ - $C_6$  alkyl-Q- $C_6$ - $C_{12}$  aryl and Q- $C_1$ - $C_6$  alkyl.

$R^c$  is selected from hydrogen and substituted or unsubstituted;  $C_1$ - $C_{10}$  alkyl,  $C_2$ - $C_{10}$  alkenyl,  $C_2$ - $C_{10}$  alkynyl,  $C_3$ - $C_{11}$  cycloalkyl,  $C_3$ - $C_{10}$  cycloalkenyl,  $C_1$ - $C_6$  alkyl- $C_6$ - $C_{12}$  aryl,  $C_6$ - $C_{10}$  aryl- $C_1$ - $C_6$  alkyl,  $C_1$ - $C_6$  alkyl-het, het- $C_1$ - $C_6$  alkyl,  $C_6$ - $C_{12}$  aryl and het, where the substituents on any alkyl, alkenyl or alkynyl are 1-3  $R^a$  and the substituents on any aryl or het are 1-3  $R^d$ .

$R^d$  is selected from  $R^p$  and  $R^h$ .

$R^h$  is selected from the group OH,  $OCF_3$ ,  $OR^c$ ,  $SR^m$ , halo(F, Cl, Br, I), CN, isocyanate,  $NO_2$ ,  $CF_3$ ,  $C_0$ - $C_6$  alkyl- $NR^{n'}R^{n'}$ ,  $C_0$ - $C_6$  alkyl-C(=O)- $NR^{n'}R^{n'}$ ,  $C_0$ - $C_6$  alkyl-C(=O)- $R^a$ ,  $C_1$ - $C_8$  alkyl,  $C_1$ - $C_8$  alkoxy,  $C_2$ - $C_8$  alkenyl,  $C_2$ - $C_8$  alkynyl,  $C_3$ - $C_6$  cycloalkyl,  $C_3$ - $C_6$  cycloalkenyl,  $C_1$ - $C_6$  alkyl-phenyl, phenyl- $C_1$ - $C_6$  alkyl,  $C_1$ - $C_6$  alkyloxycarbonyl, phenyl- $C_0$ - $C_6$  alkyloxy,  $C_1$ - $C_6$  alkyl-het, het- $C_1$ - $C_6$  alkyl,  $SO_2$ -het, -O- $C_6$ - $C_{12}$  aryl, - $SO_2$ - $C_6$ - $C_{12}$  aryl, - $SO_2$ - $C_1$ - $C_6$  alkyl and het, where any alkyl, alkenyl or alkynyl may optionally be substituted with 1-3 groups selected from OH, halo(F, Cl, Br, I), nitro, amino and aminocarbonyl and the substituents on any aryl or het are 1-2 hydroxy, halo(F, Cl, Br, I),  $CF_3$ ,  $C_1$ - $C_6$  alkyl,  $C_1$ - $C_6$  alkoxy, nitro and amino.

$R^m$  is selected from S- $C_1$ - $C_6$  alkyl, C(=O)- $C_1$ - $C_6$  alkyl, C(=O)- $NR^{n'}R^{n'}$ ,  $C_1$ - $C_6$  alkyl, halo(F, Cl, Br, I)- $C_1$ - $C_6$  alkyl, benzyl and phenyl.

$R^n$  is selected from the group  $R^c$ ,  $NH-C(=O)-O-R^c$ ,  $NH-C(=O)-R^c$ ,  $NH-C(=O)-NHR^c$ ,  $NH-SO_2-R^s$ ,  $NH-SO_2-NH-C(=O)-R^c$ ,  $NH-C(=O)-NH-SO_2-R^s$ ,  $C(=O)-O-R^c$ ,  $C(=O)-R^c$ ,  $C(=O)-NHR^c$ ,  $C(=O)-NH-C(=O)-O-R^c$ ,  $C(=O)-NH-C(=O)-R^c$ ,  $C(=O)-NH-SO_2-R^s$ ,  $C(=O)-NH-SO_2-NHR^s$ ,  $SO_2-R^s$ ,  $SO_2-O-R^s$ ,  $SO_2-N(R^c)_2$ ,  $SO_2-NH-C(=O)-O-R^c$ ,  $SO_2-NH-C(=O)-R^c$  and  $SO_2-NH-C(=O)-R^c$ .

- 5  $R^{n'}$  is selected from hydrogen, hydroxy and substituted or unsubstituted  $C_1-C_{11}$  alkyl,  $C_1-C_{11}$  alkoxy,  $C_2-C_{10}$  alkenyl,  $C_2-C_{10}$  alkynyl,  $C_3-C_{11}$  cycloalkyl,  $C_3-C_{10}$  cycloalkenyl,  $C_1-C_6$  alkyl- $C_6-C_{12}$  aryl,  $C_6-C_{10}$  aryl- $C_1-C_6$  alkyl,  $C_6-C_{10}$  aryl- $C_0-C_6$  alkyloxy,  $C_1-C_6$  alkyl-het, het- $C_1-C_6$  alkyl,  $C_6-C_{12}$  aryl, het,  $C_1-C_6$  alkylcarbonyl,  $C_1-C_8$  alkoxy carbonyl,  $C_3-C_8$  cycloalkylcarbonyl,  $C_3-C_8$  cycloalkoxy carbonyl,  $C_6-C_{11}$  aryloxy carbonyl,  $C_7-C_{11}$  arylalkoxy carbonyl,
- 10 heteroarylalkoxy carbonyl, heteroarylalkylcarbonyl, heteroarylcarbonyl, heteroarylalkylsulfonyl, heteroarylsulfonyl,  $C_1-C_6$  alkylsulfonyl and  $C_6-C_{10}$  arylsulfonyl, where the substituents on any alkyl, alkenyl or alkynyl are 1-3  $R^a$  and the substituents on any aryl, het or heteroaryl are 1-3  $R^d$ .

- Optionally,  $R^n$  and  $R^{n'}$  taken together with the common nitrogen to which they are attached may from an optionally substituted heterocycle selected from morpholinyl, piperazinyl, 15 thiamorpholinyl, pyrrolidinyl, imidazolidinyl, indolinyl, isoindolinyl, 1,2,3,4-tetrahydro-quinolinyl, 1,2,3,4-tetrahydro-isoquinolinyl, thiazolidinyl and azabicyclononyl, where the substituents are 1-3  $R^a$ .

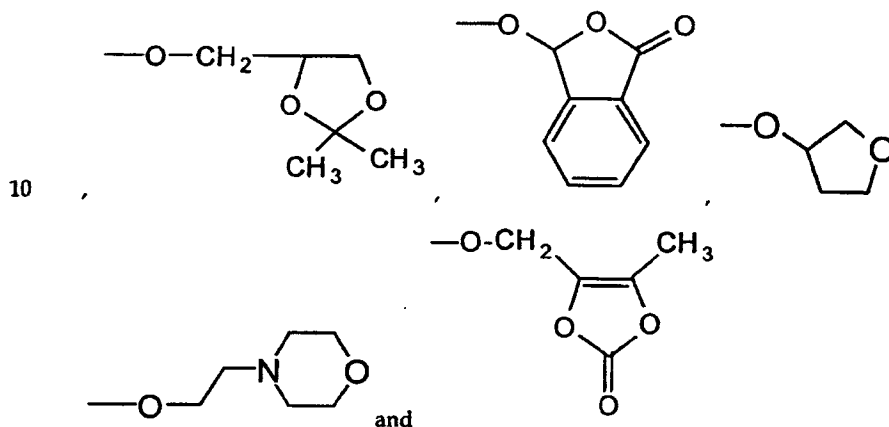
$R^o$  is selected from hydrogen and substituted or unsubstituted  $C_1-C_6$  alkyl,  $C_1-C_6$  alkylcarbonyl,  $C_2-C_6$  alkenyl,  $C_2-C_6$  alkynyl,  $C_3-C_8$  cycloalkyl and benzoyl, where the substituents on any alkyl are 1-3  $R^a$  and the substituents on any aryl are 1-3  $R^P$ .

- 20  $R^P$  is selected from the group; OH, halo(F, Cl, Br, I), CN, isocyanate,  $OR^c$ ,  $SR^m$ ,  $SOR^c$ ,  $NO_2$ ,  $CF_3$ ,  $R^c$ ,  $NR^nR^{n'}$ ,  $N(R^n)-C(=O)-O-R^c$ ,  $N(R^n)-C(=O)-R^c$ ,  $C_0-C_6$  alkyl- $SO_2-R^c$ ,  $C_0-C_6$  alkyl- $SO_2-NR^nR^{n'}$ ,  $C(=O)-R^c$ ,  $O-C(=O)-R^c$ ,  $C(=O)-O-R^c$  and  $C(=O)-NR^nR^{n'}$ , where the substituents on any alkyl, alkenyl or alkynyl are 1-3  $R^a$  and the substituents on any aryl or het are 1-3  $R^d$ .

- $R^s$  is a substituted or unsubstituted group selected from;  $C_1-C_8$  alkyl,  $C_2-C_8$  alkenyl,  $C_2-C_8$  alkynyl,  $C_3-C_8$  cycloalkyl,  $C_3-C_6$  cycloalkenyl,  $C_0-C_6$  alkyl-phenyl, phenyl- $C_0-C_6$  alkyl,  $C_0-$
- 25

$C_6$  alkyl-het and het- $C_0$ - $C_6$  alkyl, where the substituents on any alkyl, alkenyl or alkynyl are 1-3  $R^a$  and the substituents on any aryl or het are 1-3  $R^d$ .

$R^Z$  is a substituted or unsubstituted group selected from; hydroxy,  $C_1$ - $C_{11}$  alkoxy,  $C_3$ - $C_{12}$  cycloalkoxy,  $C_8$ - $C_{12}$  aralkoxy,  $C_8$ - $C_{12}$  arycycloalkoxy,  $C_6$ - $C_{10}$  aryloxy,  $C_3$ - $C_{10}$  alkylcarbonyloxyalkyloxy,  $C_3$ - $C_{10}$  alkoxycarbonyloxyalkyloxy,  $C_3$ - $C_{10}$  alkoxycarbonylalkyloxy,  $C_5$ - $C_{10}$  cycloalkylcarbonyloxyalkyloxy,  $C_5$ - $C_{10}$  cycloalkoxycarbonyloxyalkyloxy,  $C_5$ - $C_{10}$  cycloalkoxycarbonylalkyloxy,  $C_8$ - $C_{12}$  aryloxy carbonylalkyloxy,  $C_8$ - $C_{12}$  aryloxy carbonyloxyalkyloxy,  $C_8$ - $C_{12}$  arylcarbonyloxyalkyloxy,  $C_5$ - $C_{10}$  alkoxyalkylcarbonyloxyalkyloxy,  $(R^n)(R^{n'})N(C_1-C_{10} \text{ alkoxy})$



where the substituents on any alkyl, alkenyl or alkynyl are 1-3  $R^a$  and the substituents on any aryl or het are 1-3  $R^d$  and pharmaceutically acceptable salts thereof.

#### Brief Description of the Drawings

15 **FIGURE 1** A cartoon illustrating lymphocyte recruitment to a site of infection is provided. Lymphocyte rolling and adhesion to ICAM expressing cells (leukocytes, endothelium, epithelium) is shown.

**FIGURE 2** A cartoon illustrating the human ICAM-1:LFA-1 receptor binding assay (protein/protein assay) is provided. Inhibition of the CD11a/CD18-ICAM-1 interaction is quantitated by adding known amounts of inhibitors to the protein/protein assay system described in Example 3.

20 **FIGURE 3** A cartoon illustrating the human T Cell Adhesion Assay described in Example 4 is provided.



**FIGURE 4** A cartoon illustrating the human T cell proliferation assay is provided. Cell proliferation is measured by tritiated thymidine uptake.

**FIGURE 5** A cartoon illustrating the human one way mixed lymphocyte response is provided. Cell proliferation is measured by tritiated thymidine uptake.

5 **Description of the Preferred Embodiments**

**A. Definitions**

The term "LFA-1-mediated disorders" refers to pathological states caused by cell adherence interactions involving the LFA-1 receptor on lymphocytes. Examples of such disorders include T-cell inflammatory responses such as inflammatory skin diseases including psoriasis; responses associated with inflammatory bowel disease (such as Crohn's disease and ulcerative colitis); adult respiratory distress syndrome; dermatitis; meningitis; encephalitis; uveitis; allergic conditions such as eczema and asthma and other conditions involving infiltration of T-cells and chronic inflammatory responses; skin hypersensitivity reactions (including poison ivy and poison oak); atherosclerosis; leukocyte adhesion deficiency; autoimmune diseases such as rheumatoid arthritis, systemic lupus erythematosus (SLE), diabetes mellitus, multiple sclerosis, Reynaud's syndrome, autoimmune thyroiditis, experimental autoimmune encephalomyelitis, Sjorgen's syndrome, type 1 diabetes, juvenile onset diabetes, and immune responses associated with delayed hypersensitivity mediated by cytokines and T-lymphocytes typically found in tuberculosis, sarcoidosis, polymyositis, granulomatosis and vasculitis; pernicious anemia; diseases involving leukocyte diapedesis; CNS inflammatory disorder, multiple organ injury syndrome secondary to septicemia or trauma; autoimmune haemolytic anemia; myethemia gravis; antigen-antibody complex mediated diseases; all types of transplantations, including graft vs. host or host vs. graft disease; etc.

25 "Treating" such diseases includes therapy, prophylactic treatment, prevention of rejection of grafts, and induction of tolerance of grafts on a long-term basis.

The term "graft" as used herein refers to biological material derived from a donor for transplantation into a recipient. Grafts include such diverse material as, for example, isolated cells such as islet cells, tissue such as the amniotic membrane of a newborn, bone marrow, hematopoietic precursor cells, and organs such as skin, heart, liver, spleen, pancreas, thyroid lobe, lung, kidney, tubular organs (e.g., intestine, blood vessels, or esophagus), etc. The tubular organs can be used to replace damaged portions of esophagus, blood vessels, or bile duct. The skin grafts can be used not only for burns, but also as a dressing to damaged intestine or to close certain defects such as diaphragmatic hernia. The graft is derived from any mammalian source, including human, whether from cadavers or living donors. Preferably the graft is bone marrow or an organ such as heart and the donor of the graft and the host are matched for HLA class II antigens.

35 The term "mammal" refers to any animal classified as a mammal, including humans, domestic and farm animals, and zoo, sports, or pet animals, such as dogs, horses, cats, cows, etc. Preferably, the mammal herein is human.

The term "mammalian host" as used herein refers to any compatible transplant recipient. By "compatible" is meant a mammalian host that will accept the donated graft. Preferably, the host is human. If both the donor of the graft and the host are human, they are preferably matched for HLA class II antigens so as to improve histocompatibility.

5       The term "donor" as used herein refers to the mammalian species, dead or alive, from which the graft is derived. Preferably, the donor is human. Human donors are preferably volunteer blood-related donors that are normal on physical examination and of the same major ABO blood group, because crossing major blood group barriers possibly prejudices survival of the allograft. It is, however, possible to transplant, for example, a kidney of a type O donor into an A,  
10       B or AB recipient.

      The term "transplant" and variations thereof refers to the insertion of a graft into a host, whether the transplantation is syngeneic (where the donor and recipient are genetically identical), allogeneic (where the donor and recipient are of different genetic origins but of the same species), or xenogeneic (where the donor and recipient are from different species). Thus, in a typical  
15       scenario, the host is human and the graft is an isograft, derived from a human of the same or different genetic origins. In another scenario, the graft is derived from a species different from that into which it is transplanted, such as a baboon heart transplanted into a human recipient host, and including animals from phylogenically widely separated species, for example, a pig heart valve, or animal beta islet cells or neuronal cells transplanted into a human host.

20       The term "LFA-1 antagonist" as used herein generally refers to a benzoyl-amino acid (AA) derivative or a peptidomimetic thereof that acts as a competitive inhibitor of the CD11a and/or CD18 interaction with ICAM-1, soluble forms of ICAM-1 and bound or soluble forms of ICAM-2, ICAM-3 and telencephalin.

      The term "immunosuppressive agent" as used herein for adjunct therapy refers to  
25       substances that act to suppress or mask the immune system of the host into which the graft is being transplanted. This would include substances that suppress cytokine production, down regulate or suppress self-antigen expression, or mask the MHC antigens. Examples of such agents include 2-amino-6-aryl-5-substituted pyrimidines (see U.S. Pat. No. 4,665,077, *supra*, the disclosure of which is incorporated herein by reference), azathioprine (or cyclophosphamide, if there is an adverse  
30       reaction to azathioprine); bromocryptine; glutaraldehyde (which masks the MHC antigens, as described in U.S. Pat. No. 4,120,649, *supra*); anti-idiotypic antibodies for MHC antigens and MHC fragments; cyclosporin A; steroids such as glucocorticosteroids, e.g., prednisone, methylprednisolone, and dexamethasone; cytokine or cytokine receptor antagonists including anti-interferon- $\beta$ , or - $\alpha$  antibodies; anti-tumor necrosis factor- $\alpha$  antibodies; anti-tumor necrosis factor- $\beta$   
35       antibodies; anti-interleukin-2 antibodies and anti-IL-2 receptor antibodies; anti-L3T4 antibodies; heterologous anti-lymphocyte globulin; pan-T antibodies, preferably anti-CD3 or anti-CD4/CD4a antibodies; soluble peptide containing a LFA-3 binding domain (WO 90/08187 published 7/26/90), streptokinase; TGF- $\beta$ ; streptodornase; RNA or DNA from the host; FK506; RS-61443;

deoxyspergualin; rapamycin; T-cell receptor (Cohen *et al.*, U.S. Pat. No. 5,114,721); T-cell receptor fragments (Offner *et al.*, *Science*, 251:430-432 (1991); copending U.S. Ser. No. 07/853,362 filed March 18, 1992, the disclosure of which is incorporated herein by reference; Howell, WO 90/11294; laneway, *Nature*, 341:482 (1989); and Vandembark, WO 91/01133); and T-cell receptor antibodies  
5 (EP 340,109) such as T10B9. These agents are administered at the same time or at separate times from the CD11a or CD18 antagonists as used in this invention, and are used at the same or lesser dosages than as set forth in the art.

The preferred adjunct immunosuppressive agent will depend on many factors, including the type of disorder being treated including the type of transplantation being performed, as well as  
10 the patient's history, but a general overall preference is that the agent be selected from cyclosporin A, a glucocorticosteroid (most preferably prednisone or methylprednisolone), OKT-3 monoclonal antibody, azathioprine, bromocryptine, heterologous anti-lymphocyte globulin, or a mixture thereof.

"Increasing tolerance of a transplanted graft" by a host refers to prolonging the survival of  
15 a graft in a host in which it is transplanted, i.e., suppressing the immune system of the host so that it will better tolerate a foreign transplant.

The term "alkyl" means a branched or unbranched, saturated aliphatic hydrocarbon radical, having the number of carbon atoms specified, or if no number is specified, having up to 12 carbon atoms. Unless otherwise specified the term also encompasses unsaturated alkyls defined as  
20 "cycloalkyl", "alkenyl" and "alkynyl" below. Examples of preferred alkyl radicals include methyl, ethyl, n-propyl, isopropyl, n-butyl, iso-butyl, sec-butyl, tert-butyl, n-pentyl, 2-methylbutyl, 2,2-dimethylpropyl, n-hexyl, 2-methylpentyl, 2,2-dimethylbutyl, n-heptyl, 2-methylhexyl, and the like. The term "C<sub>0</sub>-C<sub>6</sub> alkyl" and similar terms containing "C<sub>0</sub>" means a covalent bond when the number of carbons is zero (C<sub>0</sub>) or C<sub>1</sub>-C<sub>6</sub> alkyl. If necessary to prevent a dangling valence the term  
25 "C<sub>0</sub>" may include a hydrogen atom. A preferred "C<sub>1</sub>-C<sub>6</sub> alkyl" group is methyl.

The term "substituted C<sub>n</sub>-C<sub>m</sub> alkyl" where m and n are integers identifying the range of carbon atoms contained in the alkyl group, denotes the above alkyl groups that are substituted by the groups listed or if no groups are listed one, two or three halogen, hydroxy, protected hydroxy, amino, protected amino, C<sub>1</sub>-C<sub>7</sub> alkoxy, nitro, carboxy, protected carboxy, carbamoyl,  
30 carbamoyloxy, cyano, methylsulfonylamino or C<sub>1</sub>-C<sub>4</sub> alkoxy groups. The substituted alkyl groups may be substituted once, twice or three times with the same or with different substituents.

Examples of the above substituted alkyl groups include but are not limited to; cyanomethyl, nitromethyl, hydroxymethyl, trityloxymethyl, propionyloxymethyl, aminomethyl, carboxymethyl, alkyloxycarbonylmethyl, allyloxycarbonylaminoethyl, carbamoyloxymethyl,  
35 methoxymethyl, ethoxymethyl, t-butoxymethyl, acetoxymethyl, chloromethyl, bromomethyl, iodomethyl, trifluoromethyl, 6-hydroxyhexyl, 2,4-dichloro(n-butyl), 2-amino(iso-propyl), 2-carbamoyloxyethyl and the like. A preferred group of examples within the above "C<sub>1</sub>-C<sub>12</sub>

substituted alkyl" group includes the substituted methyl group, e.g. a methyl group substituted by the same substituents as the "substituted C<sub>n</sub>-C<sub>m</sub> alkyl" group. Examples of the substituted methyl group include groups such as hydroxymethyl, protected hydroxymethyl (e.g. tetrahydropyranyloxymethyl), acetoxymethyl, carbamoyloxymethyl, trifluoromethyl, chloromethyl, bromomethyl and iodomethyl.

The terms "C<sub>1</sub>-C<sub>12</sub> alkyloxy" or "C<sub>1</sub>-C<sub>12</sub> alkoxy" are used interchangeably herein and denote groups such as methoxy, ethoxy, n-propoxy, isopropoxy, n-butoxy, t-butoxy and like groups.

The terms "C<sub>1</sub>-C<sub>12</sub> acyloxy" or "C<sub>1</sub>-C<sub>12</sub> alkanoyloxy" are used interchangeably and denote herein groups such as formyloxy, acetoxo, propionyloxy, butyryloxy, pentanoyloxy, hexanoyloxy, heptanoyloxy, and the like.

The terms "C<sub>1</sub>-C<sub>12</sub> alkylcarbonyl", "C<sub>1</sub>-C<sub>12</sub> alkanoyl" and "C<sub>1</sub>-C<sub>12</sub> acyl" are used interchangeably herein encompass groups such as formyl, acetyl, propionyl, butyryl, pentanoyl, hexanoyl, heptanoyl, benzoyl and the like.

The term "cycloalkyl" as used herein refers to a mono-, bi-, or tricyclic saturated or unsaturated ring, each ring having from 3 to 14 carbon atoms and preferably 3 to 7 carbon atoms. Optionally any ring carbon may be oxidized to form a carbonyl.

The term "alkenyl" means a branched or unbranched hydrocarbon radical having the number of carbon atoms designated containing one or more carbon-carbon double bonds, each double bond being independently cis, trans, or a nongeometric isomer.

The term "alkynyl" means a branched or unbranched hydrocarbon radical having the number of carbon atoms designated containing one or more carbon-carbon triple bonds.

The terms "C<sub>1</sub>-C<sub>12</sub> alkylthio" and "C<sub>1</sub>-C<sub>12</sub> substituted alkylthio" denote C<sub>1</sub>-C<sub>12</sub> alkyl and C<sub>1</sub>-C<sub>12</sub> substituted alkyl groups, respectively, attached to a sulfur which is in turn the point of attachment for the alkylthio or substituted alkylthio group to the group or substituent designated.

The term "aryl" when used alone means a homocyclic aromatic radical whether or not fused having the number of carbon atoms designated. Preferred aryl groups include phenyl, naphthyl, biphenyl, phenanthrenyl, naphthacenyl, and the like (see e.g. *Lang's Handbook of Chemistry* (Dean, J. A., ed.) 13<sup>th</sup> ed. Table 7-2 [1985]).

The term "substituted phenyl" or "substituted aryl" denotes a phenyl group or aryl group substituted with one, two or three substituents chosen from the groups listed or those selected from; halogen(F, Cl, Br, I), hydroxy, protected hydroxy, cyano, nitro, C<sub>1</sub>-C<sub>6</sub>alkyl, C<sub>1</sub>-C<sub>6</sub>alkoxy, carboxy, protected carboxy, carboxymethyl, protected carboxymethyl, hydroxymethyl, protected hydroxymethyl, aminomethyl, protected aminomethyl, trifluoromethyl N-(methylsulfonylamino) or other groups specified.

Examples of the term "substituted phenyl" includes but is not limited to a mono- or di(halo)phenyl group such as 4-chlorophenyl, 2,6-dichlorophenyl, 2,5-dichlorophenyl, 3,4-

dichlorophenyl, 3-chlorophenyl, 3-bromophenyl, 4-bromophenyl, 3,4-dibromophenyl, 3-chloro-4-fluorophenyl, 2-fluorophenyl and the like; a mono- or di(hydroxy)phenyl group such as 4-hydroxyphenyl, 3-hydroxyphenyl, 2,4-dihydroxyphenyl, the protected-hydroxy derivatives thereof and the like; a nitrophenyl group such as 3- or 4-nitrophenyl; a cyanophenyl group, for example, 4-cyanophenyl; a mono- or di(lower alkyl)phenyl group such as 4-methylphenyl, 2,4-dimethylphenyl, 2-methylphenyl, 4-(iso-propyl)phenyl, 4-ethylphenyl, 3-(n-propyl)phenyl and the like; a mono or di(alkoxy)phenyl group, for example, 2,6-dimethoxyphenyl, 4-methoxyphenyl, 3-ethoxyphenyl, 4-(isopropoxy)phenyl, 4-(t-butoxy)phenyl, 3-ethoxy-4-methoxyphenyl and the like; 3- or 4- trifluoromethylphenyl; a mono- or dicarboxyphenyl or (protected carboxy)phenyl group such 4-carboxyphenyl; a mono- or di(hydroxymethyl)phenyl or (protected hydroxymethyl)phenyl such as 3-(protected hydroxymethyl)phenyl or 3,4-di(hydroxymethyl)phenyl; a mono- or di(aminomethyl)phenyl or (protected aminomethyl)phenyl such as 2-(aminomethyl)phenyl or 2,4-(protected aminomethyl)phenyl; or a mono- or di(N-(methylsulfonylamino))phenyl such as 3-(N-methylsulfonylamino))phenyl. Also, the term "substituted phenyl" represents disubstituted phenyl groups wherein the substituents are different, for example, 3-methyl-4-hydroxyphenyl, 3-chloro-4-hydroxyphenyl, 2-methoxy-4-bromophenyl, 4-ethyl-2-hydroxyphenyl, 3-hydroxy-4-nitrophenyl, 2-hydroxy-4-chlorophenyl and the like. Preferred substituted phenyl groups include the 2- and 3-trifluoromethylphenyl, the 4-hydroxyphenyl, the 2-aminomethylphenyl and the 3-(N-(methylsulfonylamino))phenyl groups.

The term "arylalkyl" means one, two, or three aryl groups having the number of carbon atoms designated, appended to an alkyl radical having the number of carbon atoms designated including but not limited to; benzyl, naphthylmethyl, phenethyl, benzhydryl (diphenylmethyl), trityl, and the like. A preferred arylalkyl group is the benzyl group.

The term "substituted C<sub>6</sub>-C<sub>10</sub>aryl-C<sub>1</sub>-C<sub>8</sub>alkyl" denotes a C<sub>1</sub>-C<sub>8</sub>alkyl group substituted at any carbon with a C<sub>6</sub>-C<sub>10</sub>aryl group bonded to the alkyl group through any aryl ring position and substituted on the C<sub>1</sub>-C<sub>8</sub>alkyl portion with one, two or three groups chosen from halogen (F, Cl, Br, I), hydroxy, protected hydroxy, amino, protected amino, C<sub>1</sub>-C<sub>7</sub>acyloxy, nitro, carboxy, protected carboxy, carbamoyl, carbamoyloxy, cyano, C<sub>1</sub>-C<sub>6</sub>alkylthio, N-(methylsulfonylamino) or C<sub>1</sub>-C<sub>4</sub>alkoxy. Optionally the aryl group may be substituted with one, two, or three groups chosen from halogen, hydroxy, protected hydroxy, nitro, C<sub>1</sub>-C<sub>6</sub>alkyl, C<sub>1</sub>-C<sub>4</sub>alkoxy, carboxy, protected carboxy, carboxymethyl, protected carboxymethyl, hydroxymethyl, protected hydroxymethyl, aminomethyl, protected aminomethyl, or an N-(methylsulfonylamino) group. As before, when either the C<sub>1</sub>-C<sub>8</sub>alkyl portion or the aryl portion or both are disubstituted, the substituents can be the same or different.

Examples of the term "substituted C<sub>6</sub>-C<sub>10</sub>aryl-C<sub>1</sub>-C<sub>8</sub>alkyl" include groups such as 2-phenyl-1-chloroethyl, 2-(4-methoxyphenyl)ethyl, 2,6-dihydroxy-4-phenyl(n-hexyl), 5-cyano-3-methoxy-2-phenyl(n-pentyl), 3-(2,6-dimethylphenyl)n-propyl, 4-chloro-3-aminobenzyl, 6-(4-

methoxyphenyl)-3-carboxy(n-hexyl), 5-(4-aminomethyl phenyl)-3-(aminomethyl)(n-pentyl), and the like.

The term "carboxy-protecting group" as used herein refers to one of the ester derivatives of the carboxylic acid group commonly employed to block or protect the carboxylic acid group while reactions are carried out on other functional groups on the compound. Examples of such carboxylic acid protecting groups include 4-nitrobenzyl, 4-methoxybenzyl, 3,4-dimethoxybenzyl, 2,4-dimethoxybenzyl, 2,4,6-trimethoxybenzyl, 2,4,6-trimethylbenzyl, pentamethylbenzyl, 3,4-methylenedioxybenzyl, benzhydryl, 4,4'-dimethoxybenzhydryl, 2,2',4,4'-tetramethoxybenzhydryl, t-butyl, t-amyl, trityl, 4-methoxytrityl, 4,4'-dimethoxytrityl, 4,4',4''-trimethoxytrityl, 2-phenylprop-2-yl, trimethylsilyl, t-butyl dimethylsilyl, phenacyl, 2,2,2-trichloroethyl, b-(trimethylsilyl)ethyl, b-(di(n-butyl)methylsilyl)ethyl, p-toluenesulfonyl ethyl, 4-nitrobenzylsulfonyl ethyl, allyl, cinnamyl, 1-(trimethylsilylmethyl)prop-1-en-3-yl, and like moieties. The species of carboxy-protecting group employed is not critical so long as the derivatized carboxylic acid is stable to the condition of subsequent reaction(s) on other positions of the benzodiazepinedione molecule and can be removed at the appropriate point without disrupting the remainder of the molecule. In particular, it is important not to subject the carboxy-protected benzodiazepinedione molecule to strong nucleophilic bases or reductive conditions employing highly activated metal catalysts such as Raney nickel. (Such harsh removal conditions are also to be avoided when removing amino-protecting groups and hydroxy-protecting groups, discussed below.) Preferred carboxylic acid protecting groups are the allyl and p-nitrobenzyl groups. Similar carboxy-protecting groups used in the cephalosporin, penicillin and peptide arts can also be used to protect a carboxy group substituents of the benzodiazepinedione. Further examples of these groups are found in E. Haslam, "Protective Groups in Organic Chemistry", J. G. W. McOmie, Ed., Plenum Press, New York, N.Y., 1973, Chapter 5, and T.W. Greene, "Protective Groups in Organic Synthesis", John Wiley and Sons, New York, NY, 1981, Chapter 5. The term "protected carboxy" refers to a carboxy group substituted with one of the above carboxy-protecting groups.

As used herein the term "amide-protecting group" refers to any group typically used in the peptide art for protecting the peptide nitrogens from undesirable side reactions. Such groups include p-methoxyphenyl, 3,4-dimethoxybenzyl, benzyl, O-nitrobenzyl, di-(p-methoxyphenyl)methyl, triphenylmethyl, (p-methoxyphenyl)diphenylmethyl, diphenyl-4-pyridylmethyl, m-2-(picolyl)-N'-oxide, 5-dibenzosuberyl, trimethylsilyl, t-butyl dimethylsilyl, and the like. Further descriptions of these protecting groups can be found in "Protective Groups in Organic Synthesis", by Theodora W. Greene, 1981, John Wiley and Sons, New York.

Unless otherwise specified, the terms "heterocyclic group" or "heterocyclic" or "HET", "het" or "heterocyclyl" are used interchangeably as used herein refer to any mono-, bi-, or tricyclic saturated, unsaturated, or aromatic ring having the number of atoms designated where at least one ring is a 5-, 6- or 7-membered ring containing from one to four heteroatoms selected from the group nitrogen, oxygen, and sulfur (*Lang's Handbook of Chemistry, supra*). Typically, the 5-

membered ring has 0 to 2 double bonds and the 6- or 7-membered ring has 0 to 3 double bonds and the nitrogen, carbon or sulfur atoms in the ring may optionally be oxidized ( e.g. NO<sub>2</sub>, C=O and SO<sub>2</sub>) and any nitrogen heteroatom may optionally be quaternized. Included in the definition are any bicyclic groups where any of the above heterocyclic rings are fused to a benzene ring.

5 Heterocyclics in which oxygen and sulfur are the heteroatom are preferred when the heterocyclic forms all or a part of "D" in Formula I.

The following ring systems are examples of the heterocyclic (whether substituted or unsubstituted) radicals denoted by the term "heterocyclic" or "het": thienyl, furyl, pyrrolyl, imidazolyl, pyrazolyl, thiazolyl, isothiazolyl, oxazolyl, isoxazolyl, triazolyl, thiadiazolyl, 10 oxadiazolyl, tetrazolyl, thiatriazolyl, oxatriazolyl, pyridyl, pyrimidyl, pyrazinyl, pyridazinyl, thiazinyl, oxazinyl, triazinyl, thiadiazinyl, oxadiazinyl, dithiazinyl, dioxazinyl, oxathiazinyl, tetrazinyl, thiatriazinyl, oxatriazinyl, dithiadiazinyl, imidazoliny, dihydropyrimidyl, tetrahydropyrimidyl, tetrazolo[1,5-b]pyridazinyl and purinyl, as well as benzo-fused derivatives, for example benzoxazolyl, benzofuryl, benzothiazolyl, benzothiadiazolyl, benzotriazolyl, 15 benzoimidazolyl and indolyl.

Heterocyclic 5-membered ring systems containing a sulfur or oxygen atom and one to three nitrogen atoms are also suitable for use in the instant invention. Examples of such preferred groups include thiazolyl, in particular thiazol-2-yl and thiazol-2-yl N-oxide, thiadiazolyl, in particular 1,3,4-thiadiazol-5-yl and 1,2,4-thiadiazol-5-yl, oxazolyl, preferably oxazol-2-yl, and 20 oxadiazolyl, such as 1,3,4-oxadiazol-5-yl, and 1,2,4-oxadiazol-5-yl. A group of further preferred examples of 5-membered ring systems with 2 to 4 nitrogen atoms include imidazolyl, preferably imidazol-2-yl; triazolyl, preferably 1,3,4-triazol-5-yl; 1,2,3-triazol-5-yl, 1,2,4-triazol-5-yl, and tetrazolyl, preferably 1H-tetrazol-5-yl. A preferred group of examples of benzo-fused derivatives are benzoxazol-2-yl, benzthiazol-2-yl and benzimidazol-2-yl.

Further suitable specific examples of the above heterocyclic ring systems are 6-membered ring systems containing one to three nitrogen atoms. Such examples include pyridyl, such as pyrid-2-yl, pyrid-3-yl, and pyrid-4-yl; pyrimidyl, preferably pyrimid-2-yl and pyrimid-4-yl; triazinyl, preferably 1,3,4-triazin-2-yl and 1,3,5-triazin-4-yl; pyridazinyl, in particular pyridazin-3-yl, and pyrazinyl. The pyridine N-oxides and pyridazine N-oxides and the pyridyl, pyrimid-2-yl, 30 pyrimid-4-yl, pyridazinyl and the 1,3,4-triazin-2-yl radicals, are a preferred group.

The substituents for the optionally substituted heterocyclic ring systems, and further examples of the 5- and 6-membered ring systems discussed above can be found in W. Druckheimer *et al.*, U.S. Patent No. 4,278,793.

Another preferred group of "heterocyclics" or "het" include; 1,3-thiazol-2-yl, 4- (carboxymethyl)-5-methyl-1,3-thiazol-2-yl, 4-(carboxymethyl)-5-methyl-1,3-thiazol-2-yl sodium salt, 1,2,4-thiadiazol-5-yl, 3-methyl-1,2,4-thiadiazol-5-yl, 1,3,4-triazol-5-yl, 2-methyl-1,3,4-triazol-5-yl, 2-hydroxy-1,3,4-triazol-5-yl, 2-carboxy-4-methyl-1,3,4-triazol-5-yl sodium salt, 2-carboxy-4-

methyl-1,3,4-triazol-5-yl, 1,3-oxazol-2-yl, 1,3,4-oxadiazol-5-yl, 2-methyl-1,3,4-oxadiazol-5-yl, 2-(hydroxymethyl)-1,3,4-oxadiazol-5-yl, 1,2,4-oxadiazol-5-yl, 1,3,4-thiadiazol-5-yl, 2-thiol-1,3,4-thiadiazol-5-yl, 2-(methylthio)-1,3,4-thiadiazol-5-yl, 2-amino-1,3,4-thiadiazol-5-yl, 1H-tetrazol-5-yl, 1-methyl-1H-tetrazol-5-yl, 1-(1-(dimethylamino)eth-2-yl)-1H-tetrazol-5-yl, 1-(carboxymethyl)-1H-tetrazol-5-yl, 1-(carboxymethyl)-1H-tetrazol-5-yl sodium salt, 1-(methylsulfonic acid)-1H-tetrazol-5-yl, 1-(methylsulfonic acid)-1H-tetrazol-5-yl sodium salt, 2-methyl-1H-tetrazol-5-yl, 1,2,3-triazol-5-yl, 1-methyl-1,2,3-triazol-5-yl, 2-methyl-1,2,3-triazol-5-yl, 4-methyl-1,2,3-triazol-5-yl, pyrid-2-yl N-oxide, 6-methoxy-2-(n-oxide)-pyridaz-3-yl, 6-hydroxypyridaz-3-yl, 1-methylpyrid-2-yl, 1-methylpyrid-4-yl, 2-hydroxypyrimid-4-yl, 1,4,5,6-tetrahydro-5,6-dioxo-4-methyl-as-triazin-3-yl, 1,4,5,6-tetrahydro-4-(formylmethyl)-5,6-dioxo-as-triazin-3-yl, 2,5-dihydro-5-oxo-6-hydroxy-astriazin-3-yl, 2,5-dihydro-5-oxo-6-hydroxy-as-triazin-3-yl sodium salt, 2,5-dihydro-5-oxo-6-hydroxy-2-methyl-astriazin-3-yl sodium salt, 2,5-dihydro-5-oxo-6-hydroxy-2-methyl-as-triazin-3-yl, 2,5-dihydro-5-oxo-6-methoxy-2-methyl-as-triazin-3-yl, 2,5-dihydro-5-oxo-as-triazin-3-yl, 2,5-dihydro-5-oxo-2-methyl-as-triazin-3-yl, 2,5-dihydro-5-oxo-2,6-dimethyl-as-triazin-3-yl, tetrazolo[1,5-b]pyridazin-6-yl and 8-aminotetrazolo[1,5-b]pyridazin-6-yl.

An alternative group of "heterocyclics" includes; 4-(carboxymethyl)-5-methyl-1,3-thiazol-2-yl, 4-(carboxymethyl)-5-methyl-1,3-thiazol-2-yl sodium salt, 1,3,4-triazol-5-yl, 2-methyl-1,3,4-triazol-5-yl, 1H-tetrazol-5-yl, 1-methyl-1H-tetrazol-5-yl, 1-(1-(dimethylamino)eth-2-yl)-1H-tetrazol-5-yl, 1-(carboxymethyl)-1H-tetrazol-5-yl, 1-(carboxymethyl)-1H-tetrazol-5-yl sodium salt, 1-(methylsulfonic acid)-1H-tetrazol-5-yl, 1-(methylsulfonic acid)-1H-tetrazol-5-yl sodium salt, 1,2,3-triazol-5-yl, 1,4,5,6-tetrahydro-5,6-dioxo-4-methyl-as-triazin-3-yl, 1,4,5,6-tetrahydro-4-(2-formylmethyl)-5,6-dioxo-as-triazin-3-yl, 2,5-dihydro-5-oxo-6-hydroxy-2-methyl-as-triazin-3-yl sodium salt, 2,5-dihydro-5-oxo-6-hydroxy-2-methyl-as-triazin-3-yl, tetrazolo[1,5-b]pyridazin-6-yl, and 8-aminotetrazolo[1,5-b]pyridazin-6-yl.

Bivalent radicals L, whether branched or unbranched, derived from alkanes, alkenes, alkadienes, alkynes, alkadiynes, and arenes optionally containing O, N and/or S atoms, or homo- and heterocycles either aromatic or aliphatic, are designated by adding a free valence "-" to both ends of the corresponding monovalent radical. Atoms bearing the free valences may include any C, O, N or S.

"Pharmaceutically acceptable salts" include both acid and base addition salts. "Pharmaceutically acceptable acid addition salt" refers to those salts which retain the biological effectiveness and properties of the free bases and which are not biologically or otherwise undesirable, formed with inorganic acids such as hydrochloric acid, hydrobromic acid, sulfuric acid, nitric acid, carbonic acid, phosphoric acid and the like, and organic acids may be selected from aliphatic, cycloaliphatic, aromatic, araliphatic, heterocyclic, carboxylic, and sulfonic classes of organic acids such as formic acid, acetic acid, propionic acid, glycolic acid, gluconic acid, lactic acid, pyruvic acid, oxalic acid, malic acid, maleic acid, malonic acid, succinic acid, fumaric acid, tartaric acid, citric acid, aspartic acid, ascorbic acid, glutamic acid, anthranilic acid, benzoic acid,



cinnamic acid, mandelic acid, embonic acid, phenylacetic acid, methanesulfonic acid, ethanesulfonic acid, p-toluenesulfonic acid, salicylic acid and the like.

"Pharmaceutically acceptable base addition salts" include those derived from inorganic bases such as sodium, potassium, lithium, ammonium, calcium, magnesium, iron, zinc, copper, manganese, aluminum salts and the like. Particularly preferred are the ammonium, potassium, sodium, calcium and magnesium salts. Salts derived from pharmaceutically acceptable organic nontoxic bases includes salts of primary, secondary, and tertiary amines, substituted amines including naturally occurring substituted amines, cyclic amines and basic ion exchange resins, such as isopropylamine, trimethylamine, diethylamine, triethylamine, tripropylamine, ethanolamine, 2-diethylaminoethanol, trimethamine, dicyclohexylamine, lysine, arginine, histidine, caffeine, procaine, hydrabamine, choline, betaine, ethylenediamine, glucosamine, methylglucamine, theobromine, purines, piperazine, piperidine, N-ethylpiperidine, polyamine resins and the like. Particularly preferred organic non-toxic bases are isopropylamine, diethylamine, ethanolamine, trimethamine, dicyclohexylamine, choline, and caffeine.

The term "prodrug" as used herein means a derivative or precursor of a parent drug molecule that enhances pharmaceutically desirable characteristics or properties (e.g. transport, bioavailability, pharmacodynamics, etc.) and that requires biotransformation, either spontaneous or enzymatic, within the organism to release the active parent drug. Examples of carboxylic prodrugs include precursors such as aldehydes, alcohol's or amines or derivatives such as esters

#### B. Uses

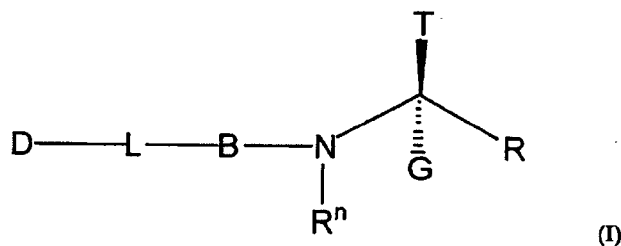
The LFA-1 and/or Mac-1 antagonists of this invention are useful for therapeutic use in those diseases and conditions for which inhibition or modulation of the LFA-1 and/or Mac-1 interaction with ICAM, especially ICAM-1, is indicated. Such diseases and conditions include: T-cell inflammatory responses such as inflammatory skin diseases including psoriasis; responses associated with inflammatory bowel disease (such as Crohn's disease and ulcerative colitis); adult respiratory distress syndrome; dermatitis; meningitis; encephalitis; uveitis; allergic conditions such as eczema and asthma, psoriasis and other conditions involving infiltration of T-cells and chronic inflammatory responses; skin hypersensitivity reactions (including poison ivy and poison oak), allergic contact dermatitis; atherosclerosis; autoimmune diseases such as rheumatoid arthritis, systemic lupus erythematosus (SLE), diabetes mellitus, multiple sclerosis, Reynaud's syndrome, autoimmune thyroiditis, experimental autoimmune encephalomyelitis, Sjorgen's syndrome, juvenile onset diabetes, and immune responses associated with delayed hypersensitivity mediated by cytokines and T-lymphocytes typically found in tuberculosis, sarcoidosis, polymyositis, granulomatosis and vasculitis; pernicious anemia; diseases involving leukocyte diapedesis; CNS inflammatory disorder, multiple organ injury syndrome secondary to septicemia or trauma; autoimmune haemolytic anemia; myasthenia gravis; antigen-antibody complex mediated diseases; all types of transplantations, including graft vs. host or host vs. graft disease, HIV infection and the like.

Other leukocyte mediated diseases for which the instant competitive inhibitors may be used include: hemorrhagic shock, ischemia/reperfusion injury, bypass surgery, burns, stroke, post CABG surgery, vasculitis, cerebral edema (broader, restenosis, AMI and non Q wave MI).

### C. Preferred Embodiments

#### 5 1. CD11a/CD18:ICAM-1 Competitive Inhibitors

One embodiment of the invention comprises a compound represented by Formula I capable of inhibiting binding of the leukocyte LFA-1 receptor to its native *in vivo* ligand(s), especially ICAM-1. Preferred inhibitors include compounds represented by structural Formula I:



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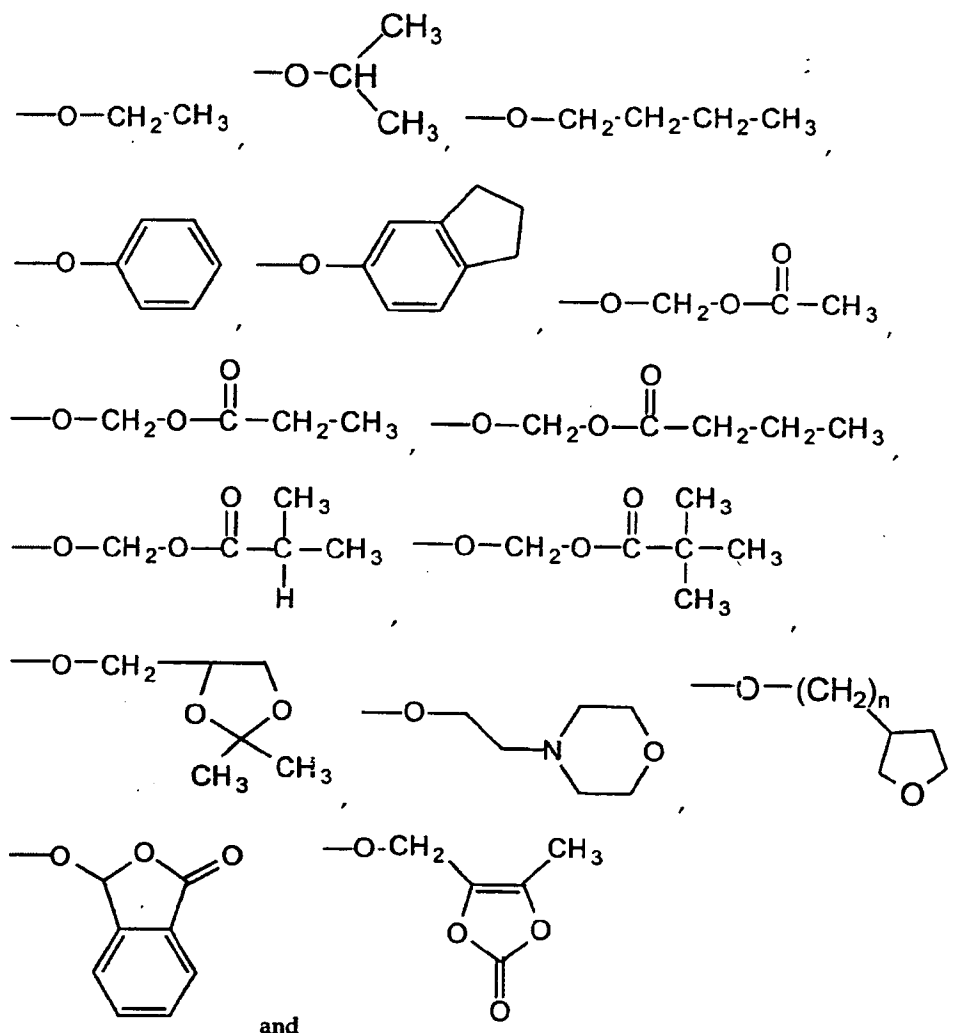
Referring to Formula I the following important structural features of the instant peptidiomimetic LFA-1 inhibitors can be identified:

- a. The negatively charged acidic moiety R or prodrug form thereof;
- b. The substituent T, a naturally occurring amino acid side chain and
- 15 derivatives thereof;
- c. The amide nitrogen(N) and substituents ( $R^n$ );
- d. The substituted "benzoyl" ring B;
- e. substituents of the B ring, namely  $R^p$ ;
- f. The spacer or linking moiety L.
- 20 g. The distal aromatic moiety D; and
- h. substituents of D, namely  $R^d$ .

#### (a) The negatively charged acidic moiety R

The preferred negatively charged acidic moiety R is the carboxyl group (-COOH) or a prodrug thereof. Generally the carboxyl group R and prodrug forms thereof is designated  $COR^Z$ .

- 25 Suitable  $R^Z$ 's include  $C_1$ -C<sub>8</sub>alkoxy,  $C_1$ -C<sub>8</sub>dialkyl-aminocarbonylmethoxy and  $C_6$ -C<sub>10</sub>aryl- $C_1$ -C<sub>8</sub>dialkylaminocarbonylmethoxy. Other suitable prodrugs  $R^Z$  includes the following groups:



and

## (b) The substituent T or U-Q-V-W

T of formula I is usually the sidechain of any  $\alpha$ -amino acid, preferably the L configuration, or a homolog or derivative thereof. Preferably T will contain a hydrogen bond donating group such as  $\text{CONH}_2$ ,  $\text{NHCOH}$ ,  $\text{NH}_2$ ,  $\text{OH}$  or  $\text{NH}$ . T will frequently be a 1-4 carbon alkane containing an amide, carbamate, ureido, sulfonamide and an optionally substituted phenyl or heterocycle. The heterocycle will usually be a 5 or 6 member ring with 1 or 2 hetero atoms selected from N, O and S. Such heterocycles include furan, thiophene, pyrrole, pyridine and piperidine. substituents include halogens such as chloro and fluoro, nitro, cyano, alkyl and halo substituted alkyl, substituted or unsubstituted amides, amines, carbamates sulfonamides, ureidos and the like.

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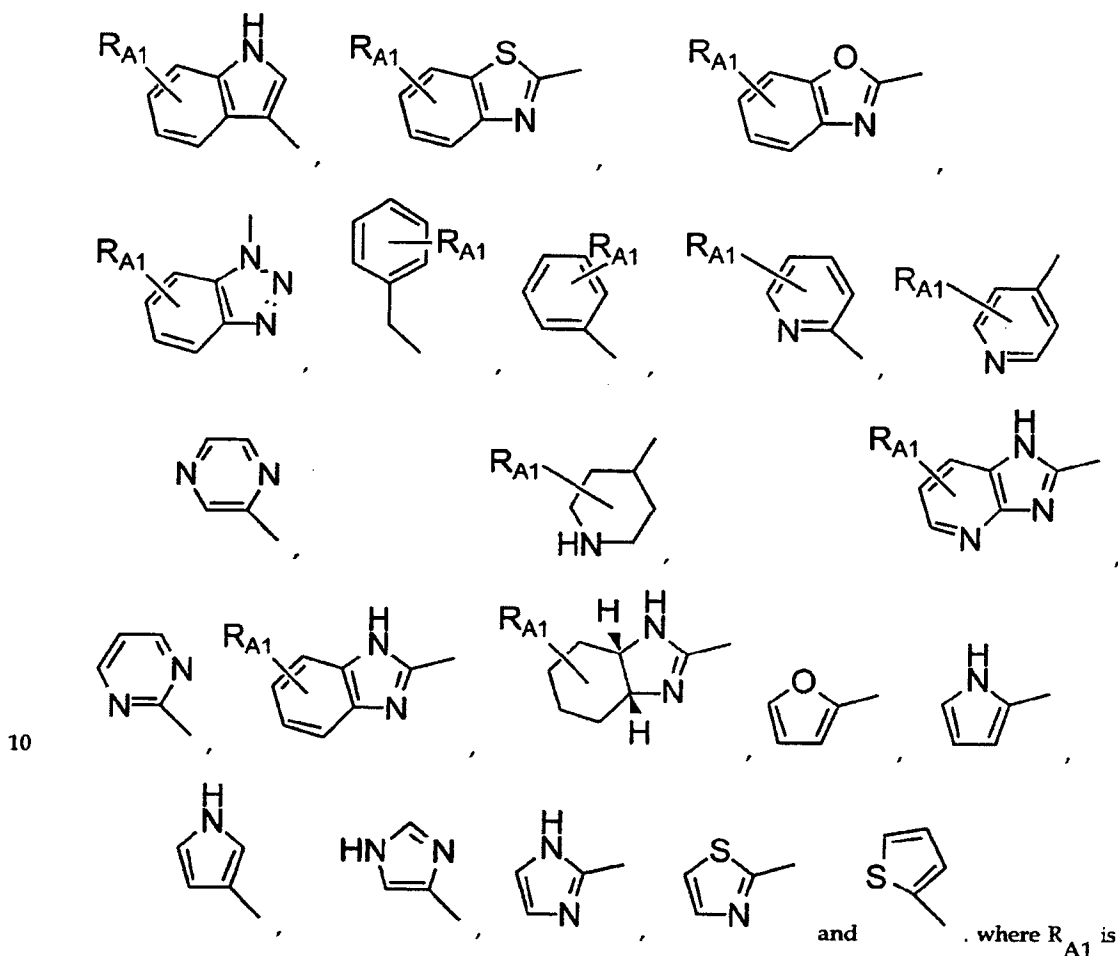
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Examples of T will also include a lower alkyl, cycloalkyl, alkenyl or alkynyl substituted with an aromatic ring, especially a heteroaryl or  $\text{C}_6\text{-C}_{14}$  aryl, substituted with 0-3  $\text{R}^d$ . Suitable aromatic rings include any mono-, bi-, or tricyclic saturated, unsaturated, or aromatic ring having

three to seven atoms in the ring, where at least one ring is a 5-, 6- or 7-membered ring containing from zero to four heteroatoms selected from the group nitrogen, oxygen, and sulfur, optionally substituted with  $R^d$ . Optionally the aromatic rings may be linked through a  $C_1$ - $C_4$  alkyl.

Preferred ring's are substituted phenyl and het as defined above optionally substituted with  $R^d$ .

5 More preferred optionally substituted aromatic ring 's are selected from the group;



0-3  $R^d$  or U-V-W.

Other optionally preferred substituents T are U-Q-V-W defined below. Specifically, T may preferably be  $-C_1-C_6$  alkyl-Q-V-W, where Q is  $-N(R^n)-$ ,  $-C(=O)-$ ,  $-N(R^n)C(=O)-$ ,  $-C(=O)-N(R^n)-$ , -

15  $-N(R^n)C(=O)-N(R^n)-$ ,  $-N(R^n)C(=O)-O-$ ,  $-O-C(=O)-N(R^n)-$ ,  $-N(R^n)S(=O)_2-$ ,  $-S(=O)_2-N(R^n)-$ ,  $-C(=O)-O-$  or  $-O-$ ; V may be het or absent and W is provided in Table 1.

Generally, each of U, Q, V and W are independently selected according to the Table 1 below. U, Q and V may also each independently be absent (i.e. one or more of U, Q, V may be a covalent bond).

Table 1

U	Q	V	W
-C <sub>1</sub> -C <sub>6</sub> alkyl-	-O-	-C <sub>1</sub> -C <sub>6</sub> alkyl-	R <sup>a</sup>
-C <sub>2</sub> -C <sub>6</sub> alkenyl-	-S(O) <sub>0-2</sub> -	-C <sub>3</sub> -C <sub>8</sub> cycloalkyl-	OR <sup>o</sup>
-C <sub>1</sub> -C <sub>6</sub> alkynyl-	-SO <sub>2</sub> N(R <sup>n</sup> )-	-C <sub>0</sub> -C <sub>6</sub> alkyl-het-	SR <sup>m</sup>
-C <sub>3</sub> -C <sub>8</sub> cycloalkyl-	-N(R <sup>n</sup> )-	-C <sub>0</sub> -C <sub>6</sub> alkyl-C <sub>6</sub> -C <sub>10</sub> aryl-	NR <sup>n</sup> R <sup>n'</sup>
-C <sub>6</sub> -C <sub>10</sub> aryl-	-N(R <sup>n</sup> )C(=O)-	-C <sub>2</sub> -C <sub>6</sub> alkenyl-	NHCOOR <sup>c</sup>
	-N(R <sup>n</sup> )C(=O)-O-	furan	NHCONR <sup>n</sup> R <sup>n'</sup>
	-N(R <sup>n</sup> )-SO <sub>2</sub> -	thiophene	NHCOR <sup>c</sup>
	-C(=O)-	pyrrole	NHSO <sub>2</sub> R <sup>s</sup>
	-C(=O)-O-	phenyl	NHSO <sub>2</sub> NR <sup>n</sup> R <sup>n'</sup>
	-het-	piperidine	NHSO <sub>2</sub> NHCOR <sup>c</sup>
	-C(=O)-N(R <sup>n</sup> )-	piperazine	NHCONHSO <sub>2</sub> R <sup>s</sup>
	-O-C(=O)-N(R <sup>n</sup> )-	morpholine	CONHCOOR <sup>c</sup>
	-PO(OR <sup>c</sup> )-O-	pyridine	CONHCOR <sup>c</sup>
	-P(O)-O-		CONHCONR <sup>n</sup> R <sup>n</sup>
			CONHSO <sub>2</sub> R <sup>s</sup>
			CONHSO <sub>2</sub> NR <sup>n</sup> R <sup>n'</sup>
			CSNR <sup>n</sup> R <sup>n'</sup>
			SO <sub>2</sub> -R <sup>s</sup>

U	Q	V	W
			$\text{SO}_3\text{R}^s$
			$\text{SO}_2\text{NR}^n\text{R}^{n'}$
			$\text{OSO}_2\text{R}^s$
			$\text{SO}_2\text{NHCOOR}^c$

Where any alkyl, alkenyl or alkynyl is substituted with 0-3  $\text{R}^a$  and any aryl or het are substituted with 0-3  $\text{R}^d$ , and where  $\text{R}^a$ ,  $\text{R}^c$ ,  $\text{R}^d$ ,  $\text{R}^m$ ,  $\text{R}^n$ ,  $\text{R}^{n'}$ ,  $\text{R}^o$  and  $\text{R}^s$  are defined above. More specifically, each of U, Q, V and W may be independently selected according to Table 2 below.

5

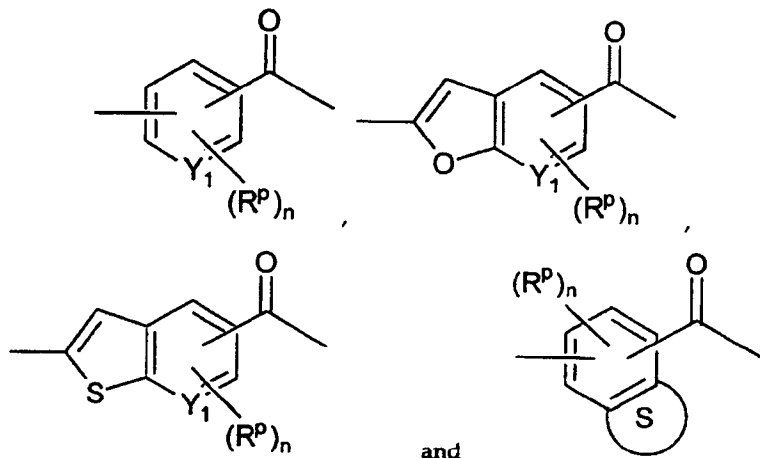
Table 2

U	Q	V	W
$-\text{CH}_2-$	$-\text{N}(\text{R}^n)\text{C}(=\text{O})-$	2-thienyl	-
$-\text{CH}_2-$	$-\text{N}(\text{R}^n)\text{C}(=\text{O})-$	2-furyl	-
$-\text{CH}_2-$	$-\text{N}(\text{R}^n)\text{C}(=\text{O})-\text{O}-$	$-\text{CH}_2-\text{CH}=\text{CH}_2$	-
$-\text{CH}_2-$	$-\text{C}(=\text{O})-\text{NH}_2$	-	-
$-\text{CH}_2-$	$-\text{N}(\text{R}^n)\text{C}(=\text{O})-$	2-thienyl	halo
$-\text{CH}_2-$	$-\text{NH}-\text{C}(=\text{O})-\text{NH}-$	phenyl	$-\text{CN}$
$-\text{CH}_2-\text{CH}_2-\text{CH}_2-$	$-\text{N}(\text{R}^n)-\text{SO}_2-$	2-thienyl	-
$-\text{CH}_2-$	$-\text{O}-\text{C}(=\text{O})-\text{NH}-$	phenyl	methyl
$-\text{CH}_2-\text{CH}_2-\text{CH}_2-$	$-\text{N}(\text{R}^n)-\text{SO}_2-$	thioimidazole	$-\text{NH}-\text{C}(=\text{O})-\text{CH}_3$
$-\text{CH}_2-\text{CH}_2-\text{CH}_2-$	$-\text{NH}-\text{SO}_2-$	phenyl	$-\text{NH}-\text{C}(=\text{O})-\text{CH}_3$
$-\text{CH}_2-\text{CH}_2-\text{CH}_2-$	$-\text{NH}-\text{SO}_2-$	2-thienyl	-
$-\text{CH}_2-$	$-\text{NH}-\text{C}(=\text{O})-$	pyrrole	tri-methyl
$-\text{CH}_2-\text{CH}_2-$	$-\text{NH}-\text{C}(=\text{O})-$	3-chloro-2-thienyl	methylsulfonyl
$-\text{CH}_2-\text{CH}_2-$	$-\text{NH}-\text{C}(=\text{O})-$	cyclopropyl	-
$-\text{CH}_2-\text{CH}_2-$	$-\text{NH}-\text{C}(=\text{O})-$	2-thienyl	chloro

U	Q	V	W
$-\text{CH}_2-$	$-\text{NH}-\text{C}(=\text{O})-$	2-furyl	methyl

(c) the substituents ( $\text{R}^n$ ) for amide nitrogen N are lower alkyl or hydrogen and preferably hydrogen.

(d) The substituted "benzoyl" ring B is preferably selected from the group:



and



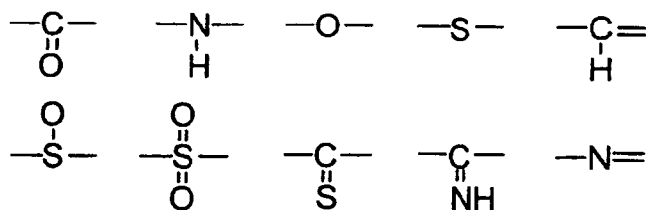
is a fused hetero- or homocyclic ring containing 5, 6 or 7 atoms, the ring being unsaturated, partially saturated or aromatic, the heteroatoms selected from 1-3 O, S or N,  $\text{Y}_1$  is selected from CH or N,  $n$  is 0-3. Preferably B is a para-substituted benzoyl group.

(e) substituents of B ( $\text{R}^p$ ) are defined above. Preferably when B is a para-substituted benzoyl group the remaining positions on B are substituted with one or more halo (F, Cl, Br) or lower alkyl groups.

5 (f) The linking group L

The length of the bivalent radical L appears to be important to optimal biological activity. By length is meant the distance between the "B" or benzoyl moiety (eg from the para position on B), including the amide or amide isostere bonded to the benzoyl moiety, and the distal group D. Preferably L is 3, 4 or 5 methylene ( $-\text{CH}_2-$ ) equivalents in length depending on the atoms in L and

10 the nature of D. Thus L is composed of  $\text{L}^1\text{-L}^3$  and optionally  $\text{L}^4$  and  $\text{L}^5$ . Each  $\text{L}^{1-5}$  is independently selected from oxo ( $-\text{O}-$ ),  $\text{S}(\text{O})$ ,  $\text{C}(=\text{O})$ ,  $\text{CR}^{1-5}\text{R}^{1'-5'}$ ,  $\text{CR}^{1-5}$ , het,  $\text{NR}^n$  or N, where s is 0-2. For example, functional groups in L (in addition to  $-\text{CH}_2-$  or  $\text{CR}^{1-5}\text{R}^{1'-5'}$ ) include one or more of the following:

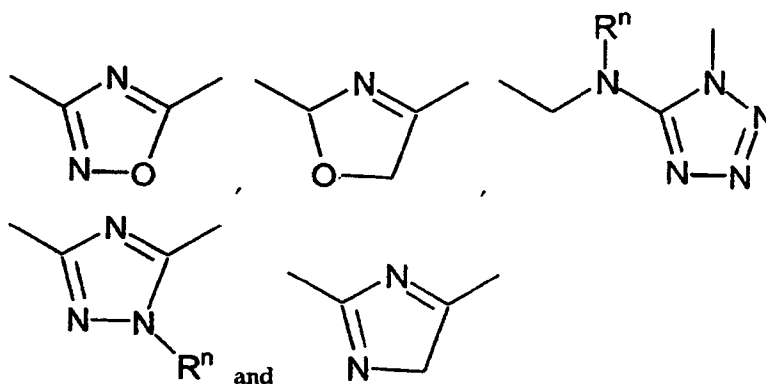


which may be located within the linker L (e.g. forming amides, imides, amidines, guanidinos, ureidos, carbamates, ethers, thioethers, ketones, sulfoxides, sulfonamides and the like) or combined in any combination, provided only that the compounds so produced are stable in aqueous solution and do not exceed the above stated length requirements. For example, preferred functional groups in L, other than a C<sub>3</sub>-C<sub>5</sub> alkyl, are: ethers, diethers, ketones, alcohols, esters, amides, ureidos, carbamates, carbonates, sulfonamides, sulfoxides, sulfones, and combinations thereof. Preferred lengths for L are from 0 to 4 while most preferred lengths are 1 or 3 methylene equivalents. In counting atoms comprising L, only those atoms sequentially linking the benzoyl moiety B and the distyl group D are counted except when a homo- or heterocycle (eg het)

10 comprises L in which case the fewest number of atoms separating these moieties are counted.

Preferred exemplary L bivalent linking groups include: -C<sub>3</sub>-C<sub>5</sub>-alkyl-, -C<sub>3</sub>-C<sub>5</sub>-alkenyl-, -CH<sub>2</sub>C(=O)NH-, -CH<sub>2</sub>NH-C(=O)-, -O-CH<sub>2</sub>-C(=O)-, -CH<sub>2</sub>-CH<sub>2</sub>-C(=O)-, -CH=CH-C(=O)NH-CH<sub>2</sub>-, -CH=CH-C(=O)NH-CH-(CH<sub>3</sub>)-, -CH(OH)-CH<sub>2</sub>-O-, -CH(OH)-CH<sub>2</sub>-CH<sub>2</sub>-, -CH<sub>2</sub>-CH<sub>2</sub>-CH(OH)-, -O-CH<sub>2</sub>-CH(OH)-CH<sub>2</sub>-, -O-CH<sub>2</sub>-CH<sub>2</sub>-CH(OH)-, -O-CH<sub>2</sub>-CH<sub>2</sub>-O-, -CH<sub>2</sub>-CH<sub>2</sub>-CH<sub>2</sub>-O-, -CH<sub>2</sub>-CH(OH)-CH<sub>2</sub>-O-, -CH<sub>2</sub>-CH<sub>2</sub>-O-, -CH(OH)-CH<sub>2</sub>-O-, -CH-(CH<sub>3</sub>)-NH-C(=O)-, -CH<sub>2</sub>NH-SO<sub>2</sub>-, -NH-SO<sub>2</sub>-CH<sub>2</sub>-, -CH<sub>2</sub>-SO<sub>2</sub>NH-, -SO<sub>2</sub>NH-CH<sub>2</sub>-, -C(=O)-NH-C(=O)-, -NH-C(=O)-NH-, -NH-C(=O)-NH-CH<sub>2</sub>-, -CH<sub>2</sub>NH-C(=O)-NH-, -C(=O)-NH-CH<sub>2</sub>-C(=O)-NH-, -NH-C(=O)-O- and -O-C(=O)-NH-.

Preferred exemplary L bivalent linking groups containing a heterocycle include:

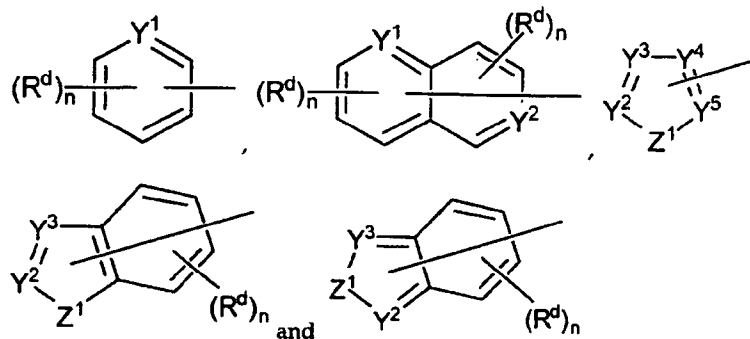


15 Any carbon in the bivalent linking groups may optionally be substituted with a halogen, especially fluorine.



(g) The distal moiety D may be a mono-, bi-, or tricyclic saturated, unsaturated, or aromatic ring, each ring having 5-, 6- or 7 atoms in the ring where the atoms in the ring are carbon or from 1-4 heteroatoms selected from; nitrogen, oxygen, and sulfur, each ring substituted with 0-3  $R^d$ .

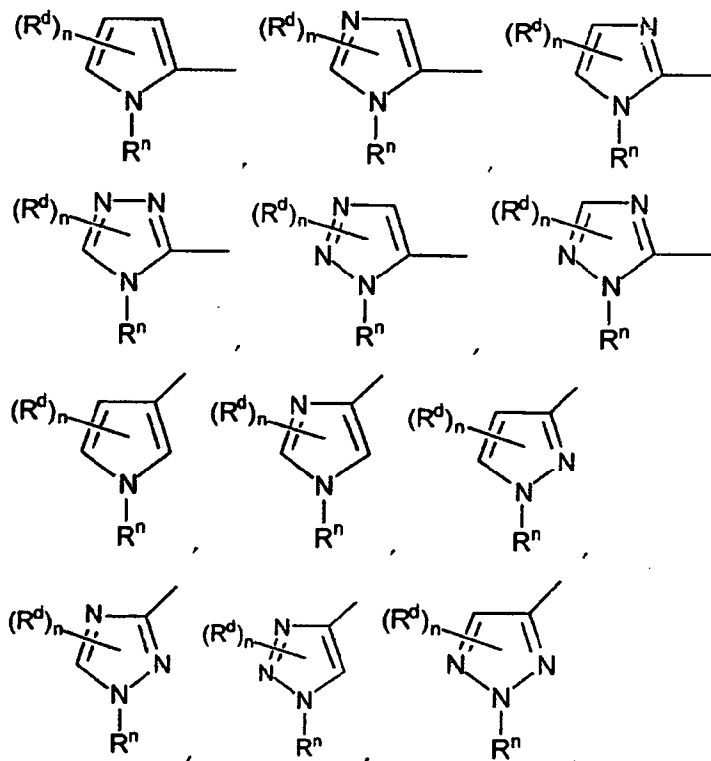
Optionally, D is an aromatic homocycle or aromatic heterocycle containing 1-3 heteroatoms selected from the group N, S and O, the homo- or hetero-cycles selected from:

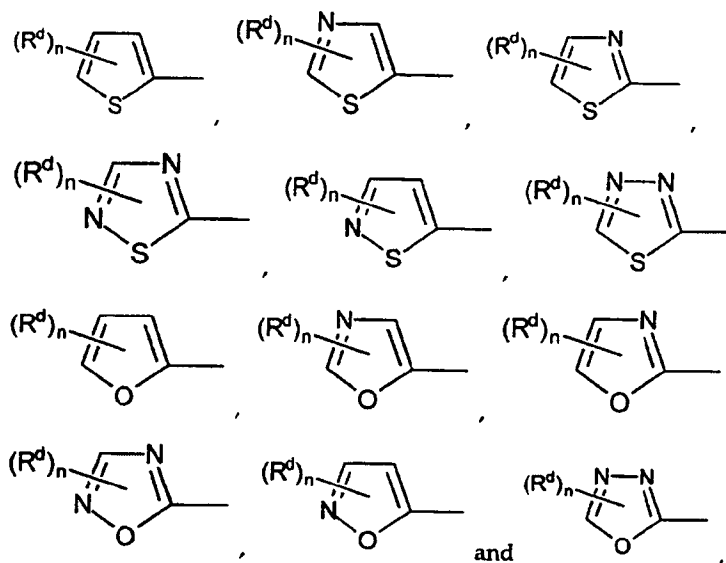


where  $Y^1, Y^2, Y^3, Y^4$  and  $Y^5$  are CH,  $CR^d$  or N,  $Z^1$  is O, S, NH or  $NR^n$  and n is 0-3.

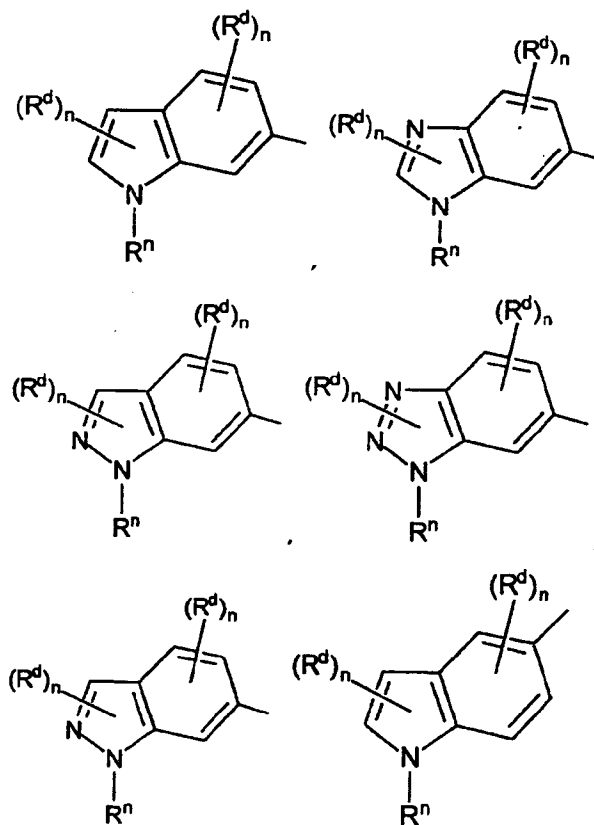
More specifically, D may be:

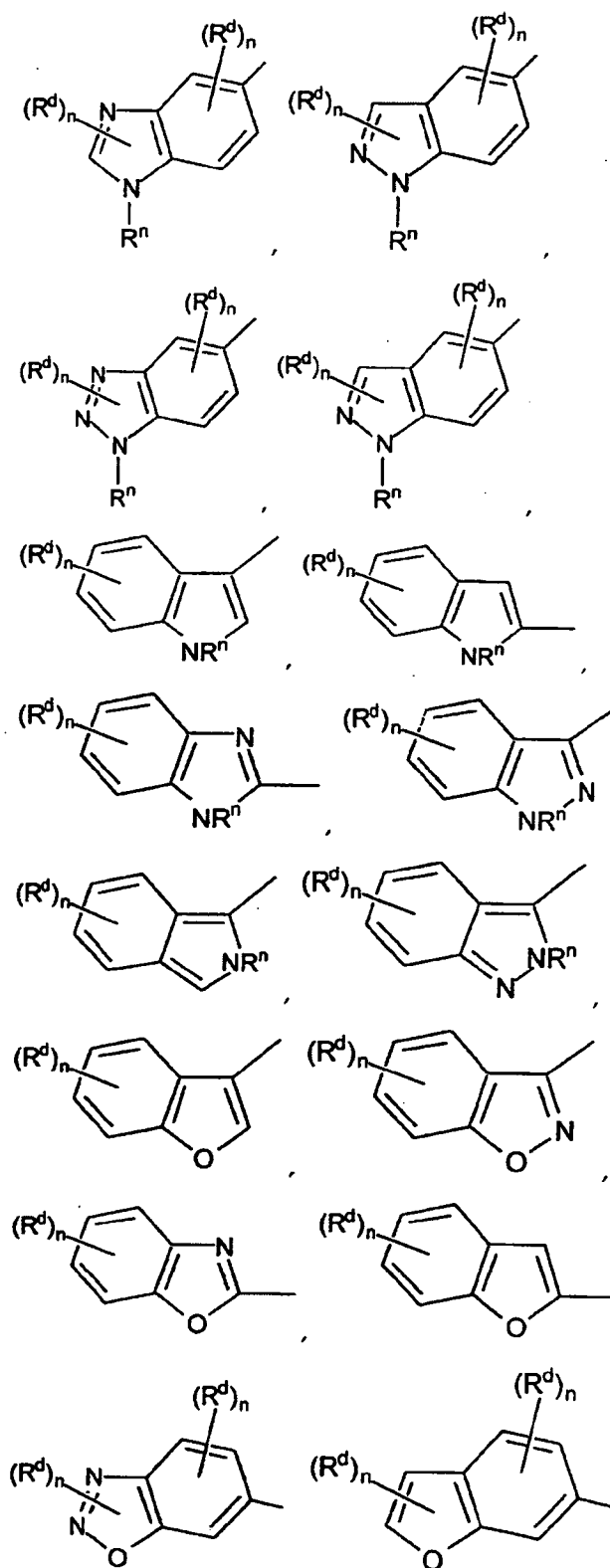
1) a 5-member aromatic heterocycle selected from;

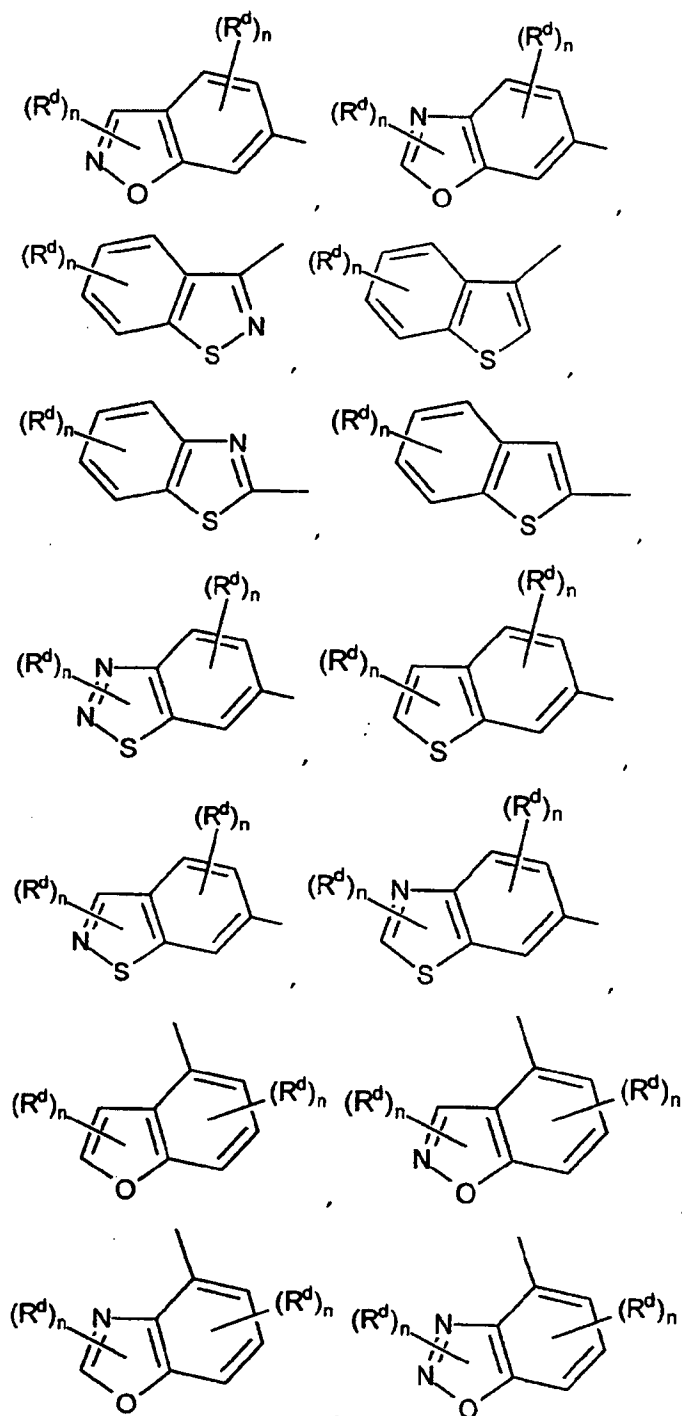


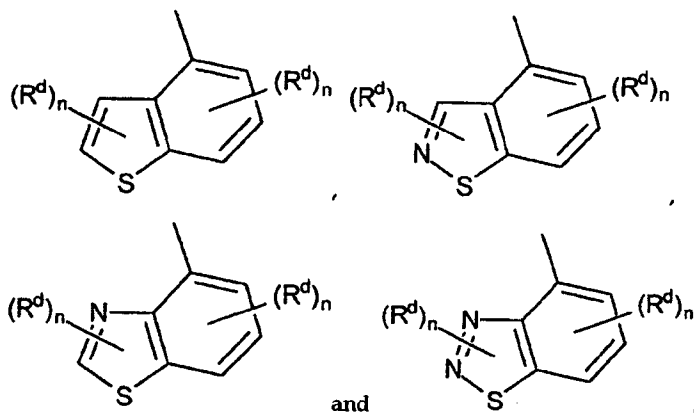


2) a 9-member aromatic heterobicycle selected from;

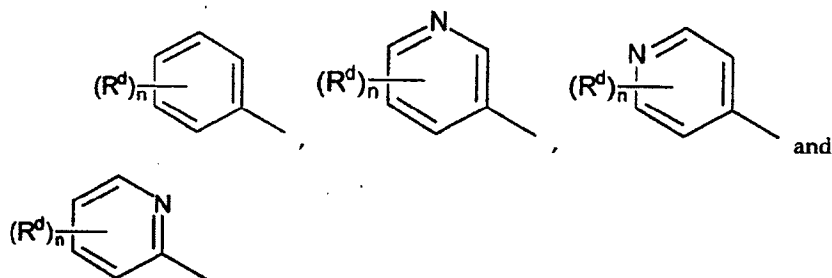








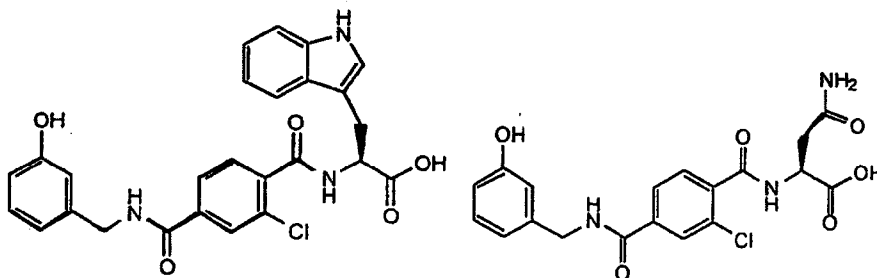
3) a 6-member aromatic hetero- or homocycle selected from;

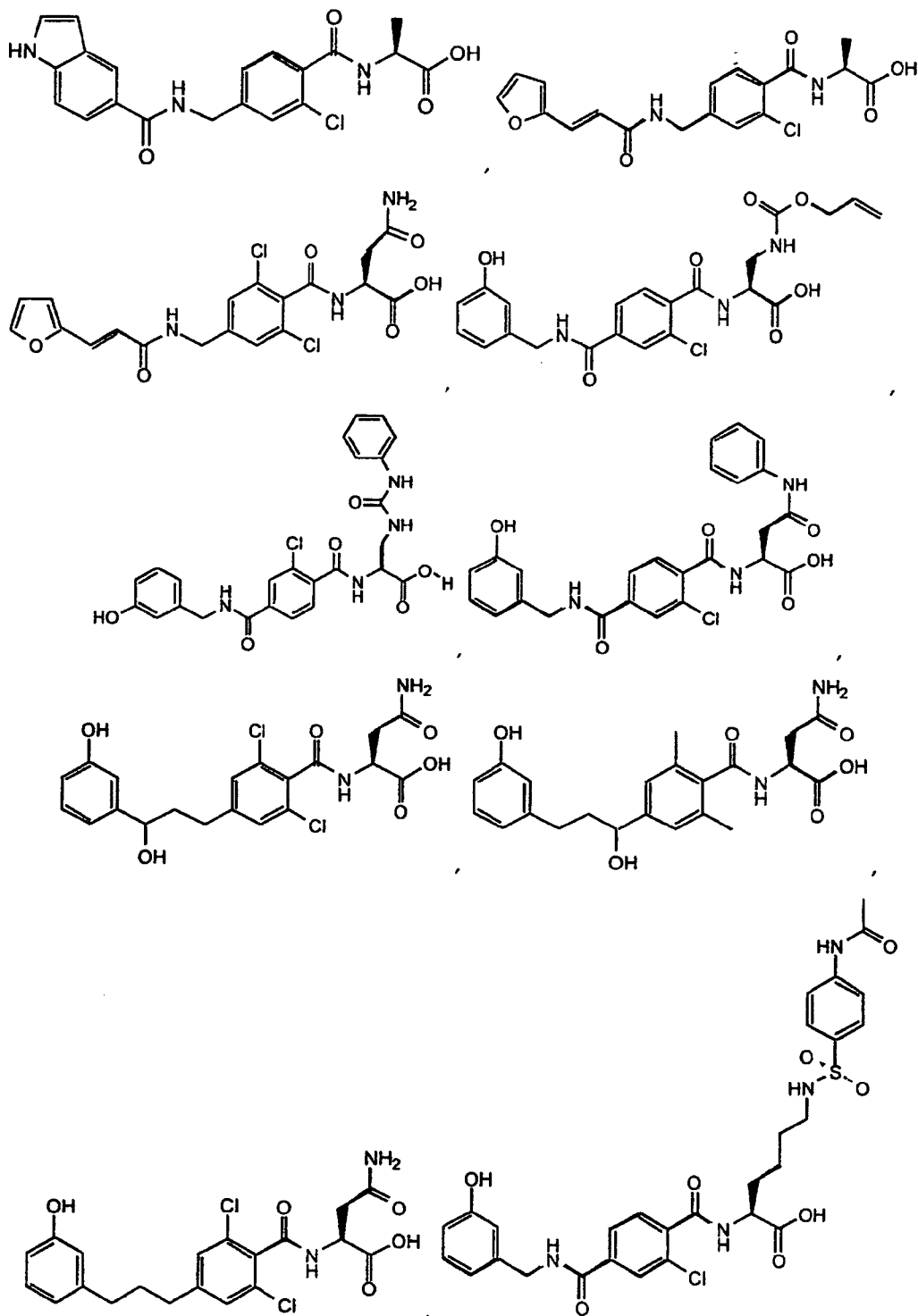


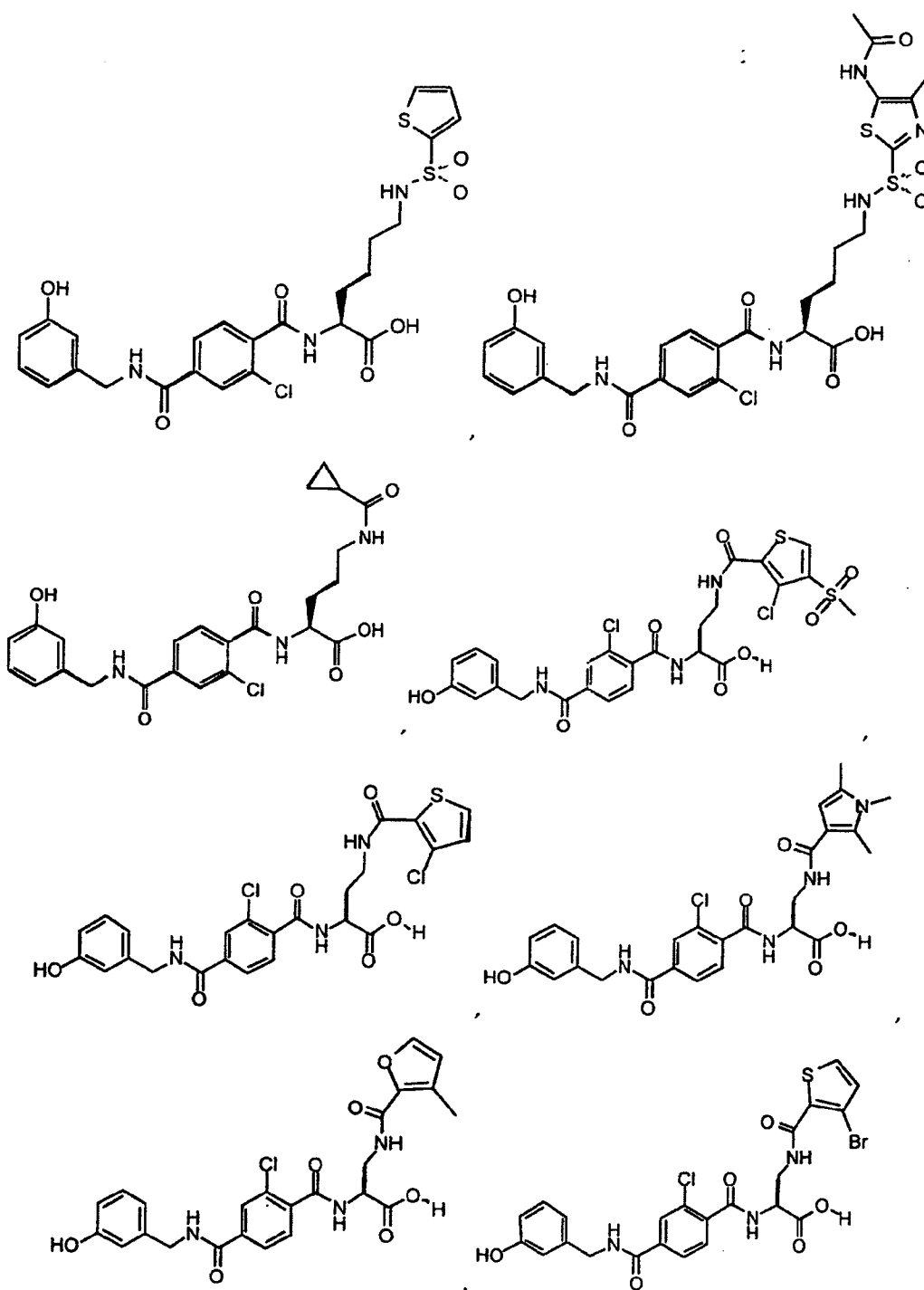
Compounds containing the foregoing preferred 5-member aromatic heterocycle and 9-member aromatic heterobicycle, 1 and 2 above, as aromatic groups D are preferred as LFA-1 specific antagonists, while the 6-member aromatic hetero- or homocycles of 3 above are preferred as D groups suitable for inhibiting both LFA-1 and Mac-1. In this latter case D is preferably substituted with a hydroxyl or precursor thereof.

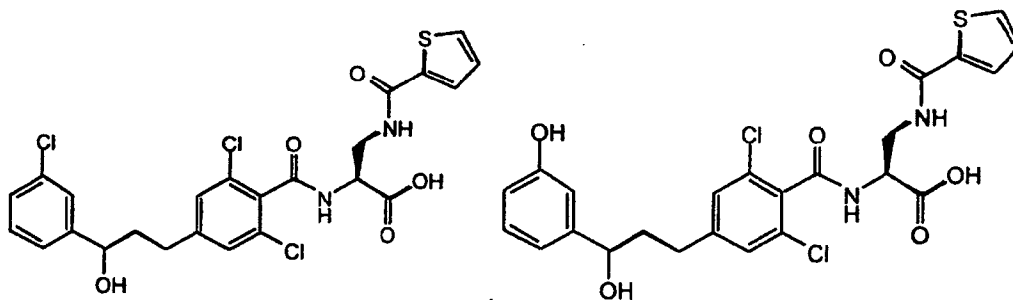
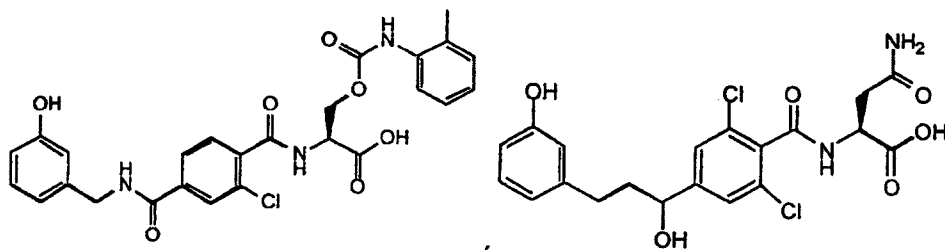
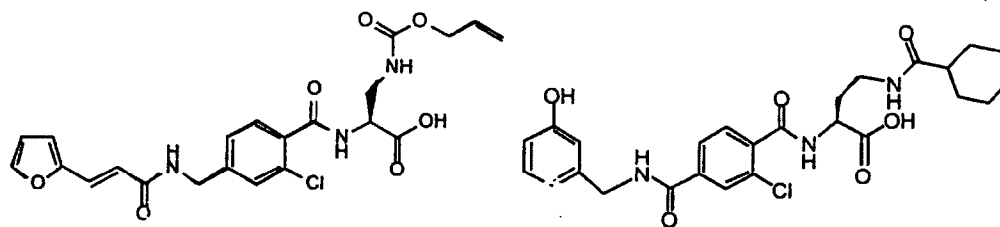
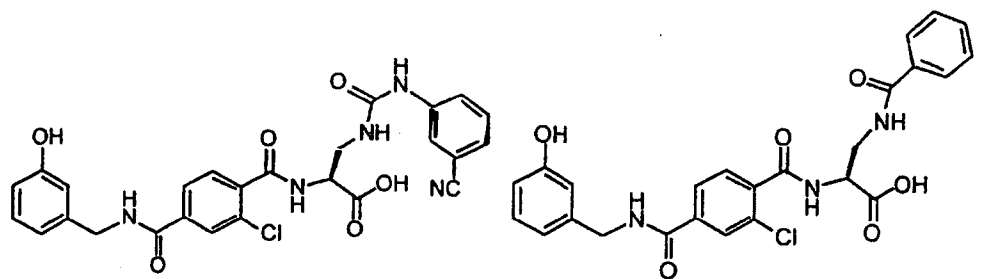
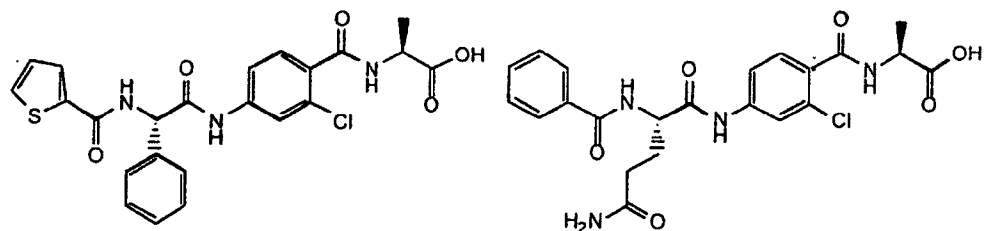
(h) Preferred substituents of D are one or more groups selected from; OH, NH<sub>2</sub>, SO<sub>2</sub>NH<sub>2</sub>, SO<sub>2</sub>CH<sub>3</sub>, CH<sub>3</sub>, CH<sub>2</sub>OH, CN, CH<sub>3</sub>-C(=O)NH-, NH<sub>2</sub>-C(=O)-, NHCONH<sub>2</sub>, CF<sub>3</sub>, C<sub>1</sub>-C<sub>6</sub> alkoxy and halo(F, Cl, Br and I).

Exemplary preferred compounds of this invention include:



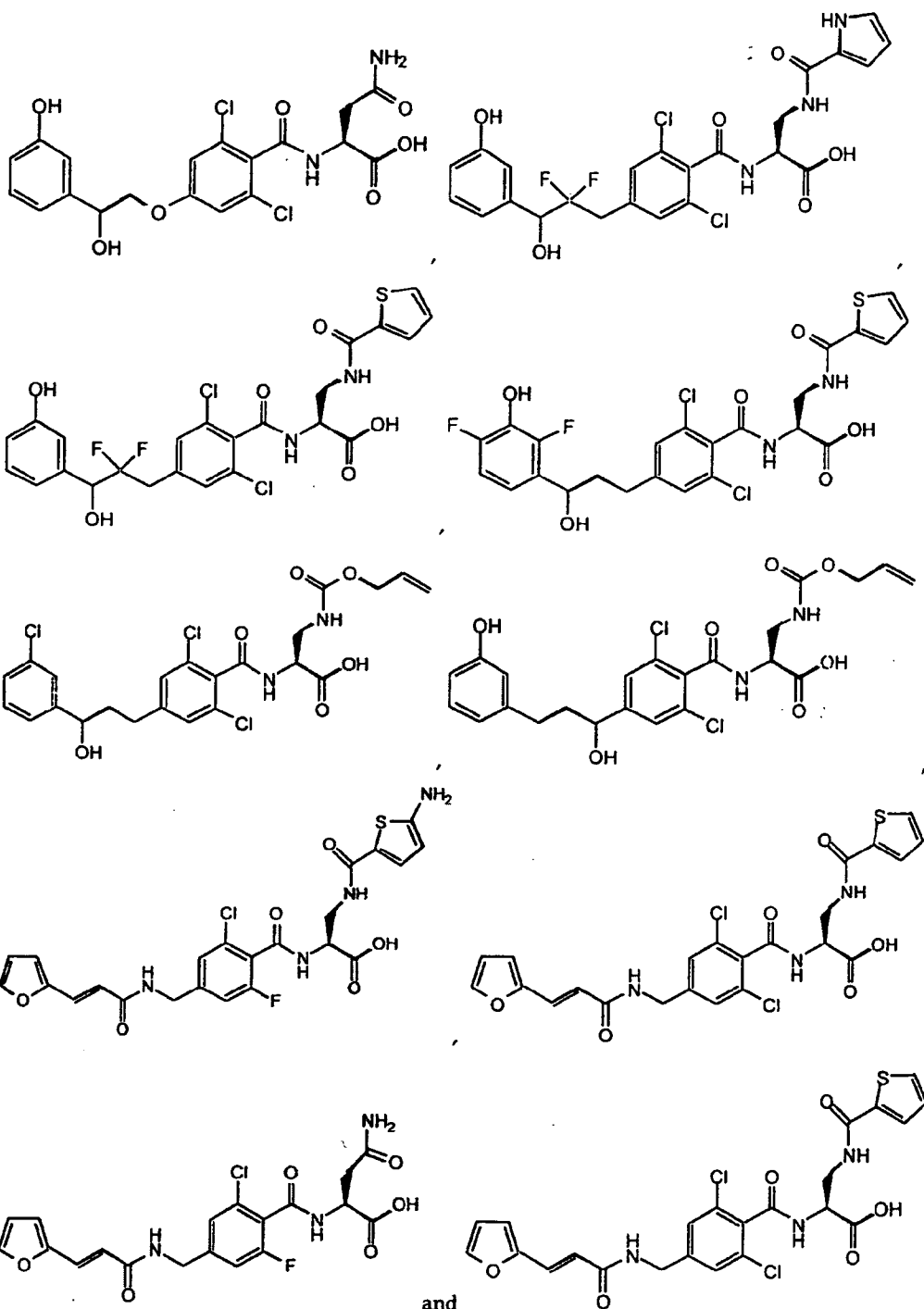






5





#### D Methods of Making

One method of producing LFA-1 antagonists involves chemical synthesis of the "peptide" or peptidomimetic. This can be accomplished using methodologies well known to those skilled in the

art (see Stewart and Young, *Solid Phase Peptide Synthesis* Pierce Chemical Co. Rockford, IL (1984); see also U. S. Patent No.'s 4,105,603; 3,972,859; 3,842,067; and 3,862,925)).

It will be appreciated from inspection of the compounds shown above that they all contain one or more amide or peptide bonds and thus may be considered peptidomimetics. Peptidomimetics of the invention may also be conveniently prepared using solid phase peptide synthesis (Merrifield, *J. Am. Chem. Soc.*, 85:2149 (1964); Houghten, *Proc. Natl. Acad. Sci. USA* 82:5132 (1985)). Solid phase synthesis begins at the carboxy-terminus of the putative peptide by coupling a protected amino acid to a suitable resin (e.g. chloromethylated polystyrene resin) as shown in Figures 1-1 and 1-2, on pages 2 and 4 of Stewart and Young *supra*. After removal of the  $\alpha$ -amino protecting group with, for example, trifluoroacetic acid (TFA) in methylene chloride and neutralizing in, for example TEA, the next  $\alpha$ -amino- and sidechain protected amino acid in the synthesis is added. The remaining  $\alpha$ -amino- and, if necessary, side-chain-protected amino acids are then coupled sequentially in the desired order by condensation to obtain an intermediate compound connected to the resin. Alternatively, some amines and acids may be coupled to one another forming a peptide prior to addition of the peptide to the growing solid phase peptide chain.

The condensation between two amino acids can be carried out according to the usual condensation methods such as the azide method, mixed acid anhydride method, DCC (N,N'-dicyclohexylcarbodiimide) or DIPC (N,N'-diisopropylcarbodiimide) methods, active ester method (p-nitrophenyl ester method, BOIP [benzotriazole-1-yl-oxy-tris (dimethylamino) phosphonium hexafluorophosphate] method, N-hydroxysuccinic acid imido ester method, etc., and Woodward reagent K method.

Common to chemical syntheses of peptides is the protection of any reactive side-chain groups of the amino acids with suitable protecting groups. Ultimately these protecting groups are removed after the desired polypeptide chain has been sequentially assembled. Also common is the protection of the  $\alpha$ -amino group on an amino acid or a fragment while that entity reacts at the carboxyl group followed by the selective removal of the  $\alpha$ -amino-protecting group to allow subsequent reaction to take place at that location. Accordingly, it is common in peptide synthesis that an intermediate compound is produced which contains each of the amino acid residues located in the desired sequence in the peptide chain with various of these residues having side-chain protecting groups attached. These protecting groups are then commonly removed substantially at the same time so as to produce the desired resultant product following removal from the resin.

Suitable protective groups for protecting the  $\alpha$ - and  $\epsilon$ - amino side chain groups are exemplified by benzyloxycarbonyl (CBZ), isonicotinylloxycarbonyl (iNOC), O-chlorobenzyloxycarbonyl (2-Cl-CBZ), p-nitrobenzyloxycarbonyl [Z(NO<sub>2</sub>)], p-methoxybenzyloxycarbonyl [Z(OMe)], t-butoxycarbonyl (BOC), t-amylloxycarbonyl (AOC), isobornylloxycarbonyl, adamantylloxycarbonyl, 2-(4-biphenyl)-2-propyl-oxycarbonyl (BPOC), 9-fluorenylmethoxycarbonyl (Fmoc), methylsulfo-nyiethoxycarbonyl (Msc), trifluoroacetyl, phthalyl,

formyl, 2-nitrophenylsulphenyl (NPS), diphenylphosphinothioyl (Ppt), dimethylphosphinothioyl (Mpt) and the like.

Protective groups for the carboxy functional group are exemplified by; benzyl ester (OBzl), cyclohexyl ester (Chx), 4-nitrobenzyl ester (ONb), t-butyl ester (OtBu), 4-pyridylmethyl ester (OPic), and the like. It is often desirable that specific amino acids such as arginine, cysteine, and serine possessing a functional group other than amino and carboxyl groups are protected by a suitable protective group. For example, the guanidino group of arginine may be protected with nitro, p-toluenesulfonyl, benzyloxycarbonyl, adamantyloxycarbonyl, p-methoxybenzenesulfonyl, 4-methoxy-2, 6-dimethylbenzenesulfonyl (Mds), 1,3,5-trimethylphenylsulfonyl (Mts), and the like. The thiol group of cysteine may be protected with p-methoxybenzyl, triphenylmethyl, acetylaminoethyl ethylcarbamoyle, 4-methylbenzyl, 2, 4, 6-trimethylbenzyl (Tmb) etc., and the hydroxyl group of serine can be protected with benzyl, t-butyl, acetyl, tetrahydropyranyl and the like.

Stewart and Young *supra* provides detailed information regarding procedures for preparing peptides. Protection of  $\alpha$ -amino groups is described on pages 14-18, and side-chain blockage is described on pages 18-28. A table of protecting groups for amine, hydroxyl and sulfhydryl functions is provided on pages 149-151.

After the desired amino acid sequence has been completed, the intermediate peptide is removed from the resin support by treatment with a reagent, such as liquid HF and one or more sulfur-containing scavengers, which not only cleaves the peptide from the resin, but also cleaves all the remaining side-chain protecting groups. Following HF cleavage, the peptide residue is washed with ether, and extracted from the resin by washing with aqueous acetonitrile and acetic acid.

Preferably in order to avoid alkylation of residues in the polypeptide, (for example, alkylation of methionine, cysteine, and tyrosine residues) a thio-cresol and cresol scavenger mixture is used.

#### Other General Procedures

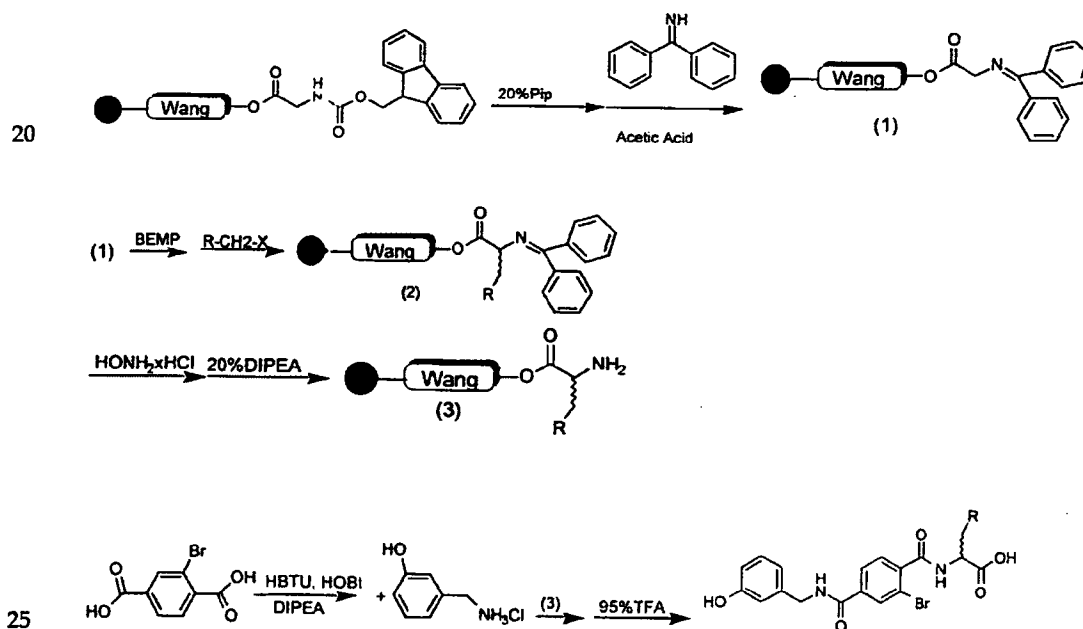
The peptidomimetic compounds of this invention may also be conveniently prepared by the methods for peptide synthesis described in monographs such as ("Principles of Peptide Synthesis, M. Bodanszky, Springer-Verlag, 2nd Ed., 1993; "Synthetic Peptides: A Users Guide", G. A. Grant, Ed, W. H. Freeman and Co., 1992; and references cited therein), or by other methods generally known to one skilled in the art. The synthesis of compounds of this invention that are peptidomimetic in nature (*i.e.* contain other than standard amide bond linkages between two or more amino acids) may be prepared by extension of the methods described in Examples 6 and by the general synthetic methods described in "Comprehensive Organic Transformations", R. C. Larock, VCH Publishers, 1989, and by methods generally known to one skilled in the art.

For compounds of Claim 1 where the amide linkages (-C(=O)-NH-) are replaced with amide isostere (Ai) linkages such as; (-C(=S)-NH-), (-S(=O)<sub>2</sub>-NH-), -CH<sub>2</sub>-NH-, -CH<sub>2</sub>-S-, -CH<sub>2</sub>-O-, -CH<sub>2</sub>-CH<sub>2</sub>-, -CH=CH- (cis and trans), -C(=O)-CH<sub>2</sub>-, -CH(OH)-CH<sub>2</sub>-, -CH(CN)-NH-, -O-C(=O)-NH-

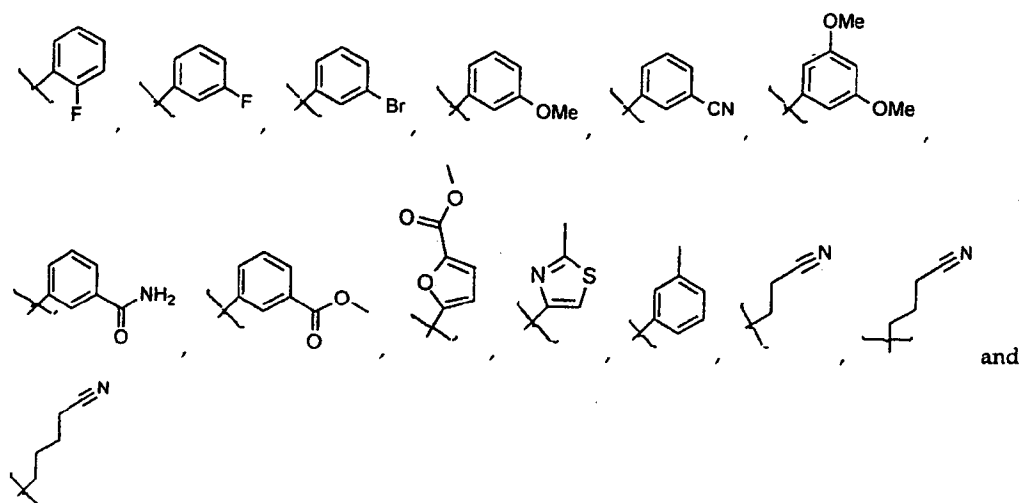
and  $-\text{CH}_2\text{SO}-$ , amide bond replacing methods known in the art are employed. The following references describe preparation of amide isostere linkages which include these alternative-linking moieties: Spatola, A.F., Vega Data 1(3): "Peptide Backbone Modifications" (General Review) (Mar 1983), Spatola, A.F., in "Chemistry and biochemistry of Amino Acids Peptides and Proteins", B. Weinstein, ed., Marcel Dekker, New York, P. 267 (1983); Morley *Trends Pharm. Sci.* pp. 463-468; Hudson *et al.* *Int. J. Pept. Prot. Res.* 14:177-185 (1979) ( $-\text{CH}_2\text{NH}-$ ,  $-\text{CH}_2\text{CH}_2-$ ); Spatola *et al.*, *Life Sci.* 38:1243-1249 (1986) ( $-\text{CH}_2\text{S}-$ ); Hann *J. Chem. Soc. Perkin. Trans. I* 307-314 (1982) ( $-\text{CH}=\text{CH}-$ , cis and trans); Almquist *et al.*, *J. Med. Chem.* 23:1392-1398 (1980) ( $-\text{C}(=\text{O})-\text{CH}_2-$ ); Jennings-White *et al.*, *Tetrahedron Lett* 23:(1982) ( $-\text{C}(=\text{O})-\text{CH}_2-$ ); Szelke *et al.*, EP Application No. 45665 (1982) *Chem Abs* :9739405 (1982) ( $-\text{CH}(\text{OH})-\text{CH}_2-$ ); Holladay *et al.*, *Tetrahedron Lett* 24:4401-4404 (1983) ( $-\text{C}(\text{OH})-\text{CH}_2-$ ); Hruby *Life Sci* 31:189-199 (1982) ( $-\text{CH}_2\text{S}-$ ); Cho *et al.*, *Science* 261:1303-1305 (1993) ( $-\text{O}-\text{C}(=\text{O})-\text{NH}-$ ); Sherman *et al.*, *Biochem Biophys Res Comm* 162(3):1126-1132 (1989) ( $-\text{C}(=\text{S})-\text{NH}-$ ); Calcagni *et al.*, *Int. J. Peptide Protein Res.* 34:319-324 (1989) ( $-\text{S}(=\text{O})_2-\text{NH}-$ ); TenBrink, *J. Org. Chem.* 52:418-422 (1987)  $-\text{CH}_2\text{O}-$ .

Scheme I illustrates one synthetic approach which provides access to unnatural amino acid sidechains particularly for substituent T of Formula I. The method provides for  $\alpha$ -alkylation of the "glycine" sidechain using a solid phase approach on a commercially available machine, such as an Argonaut Nautilus 2400.

Scheme I



The following representative "R" groups can be introduced into the LFA-1 antagonists by the alkylation scheme above:

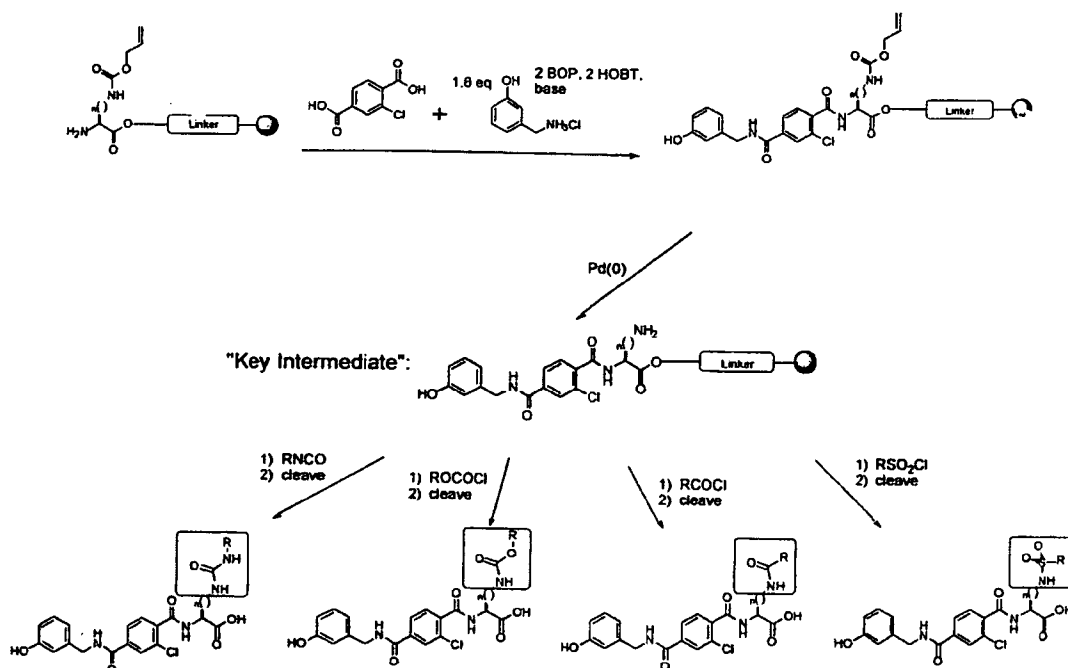


- 5 When "R" of Scheme I is an alkyl amine, prepared from the amino acids lys. orn or DAPA, reduction of the representative nitriles above or prepared from the protected (e.g. Fmoc) aminoalkyl halide, synthetic routes are available to make derivatives of T including urea's, carbamates, imides and sulfonamides by known procedures.

Scheme II illustrates a solid phase approach for producing these derivatives of T.

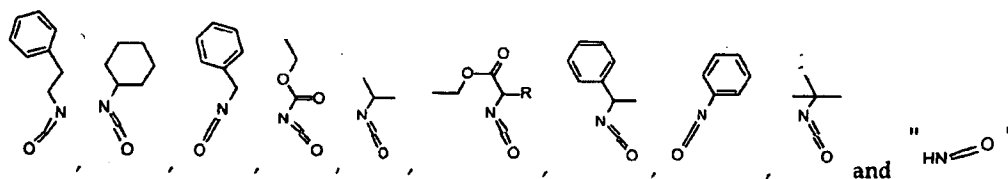
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Scheme II

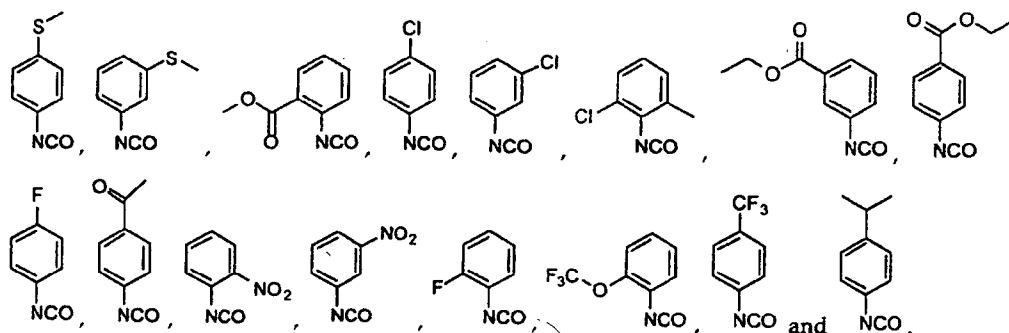


15

Urea's made according to Scheme II can be synthesized from representative commercially available isocyanates, RNCO's, including the following:

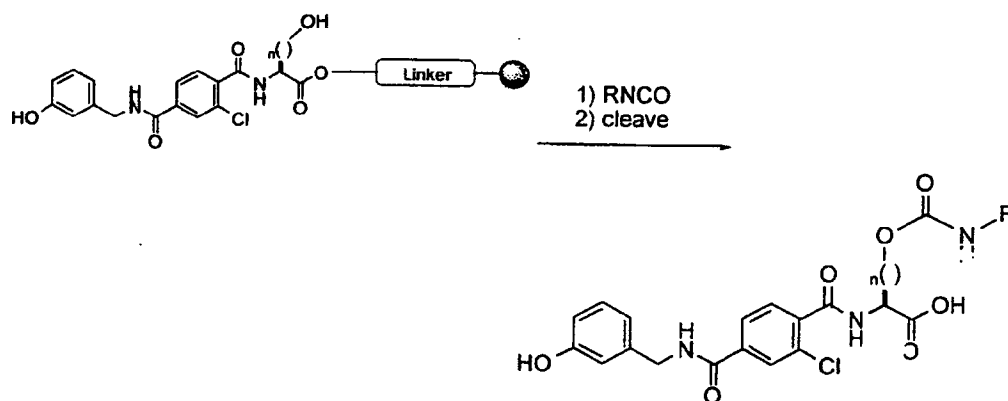


Other representative substituted aryl isocyanates suitable for use in the above scheme include:



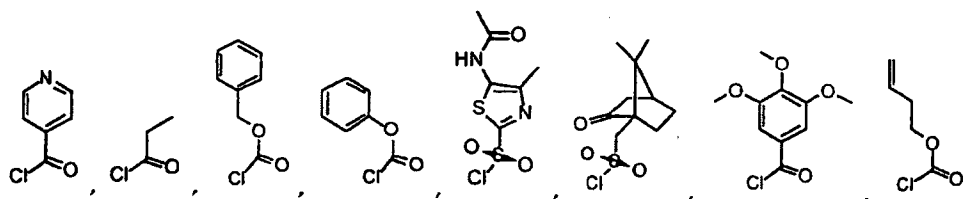
5 These and other isocyanates may be used to produce carbamates when the "R" in Scheme I is an alcohol (e.g. ser) according to scheme Scheme IIa below.

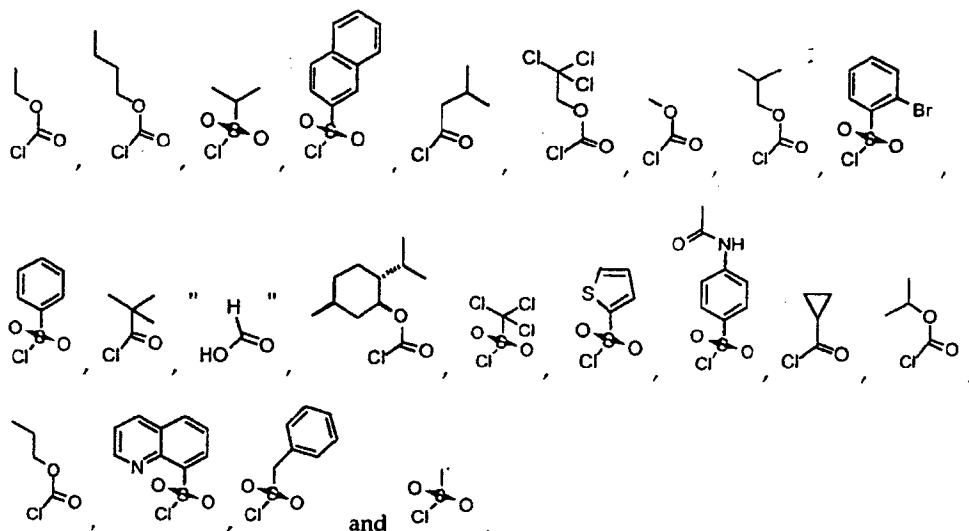
### Scheme IIa



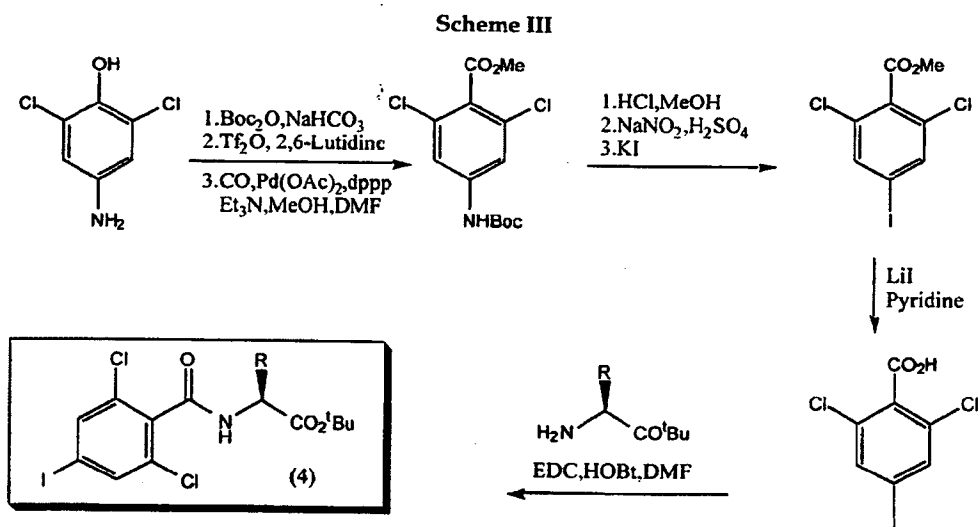
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Carbamates (of the opposite orientation to Scheme IIa), amides and sulfonamides synthesized according to Scheme II can be made from representative commercially available  $\text{ROCOCl}$ 's,  $\text{RCOCl}$ 's and  $\text{RSO}_2\text{Cl}$ 's including the following:





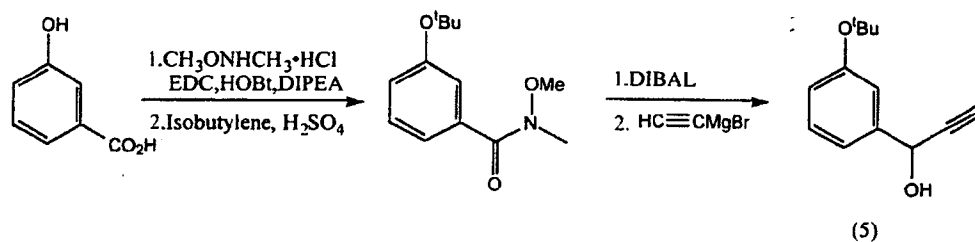
5 Scheme III illustrates a general synthetic route for alkyl linkers, L, for dichloro-substituted benzoyl-amino acids or derivatives thereof. The key intermediate in this approach is the iodo, dichloro-benzoyl-AA (4).



10 Key intermediate (4) is coupled to a variety of alkynes to produce alkyl linkers of various length. For example a 3 carbon linker can be made by coupling (4) to alkyne intermediate (5) prepared according to Scheme IIIa.

15

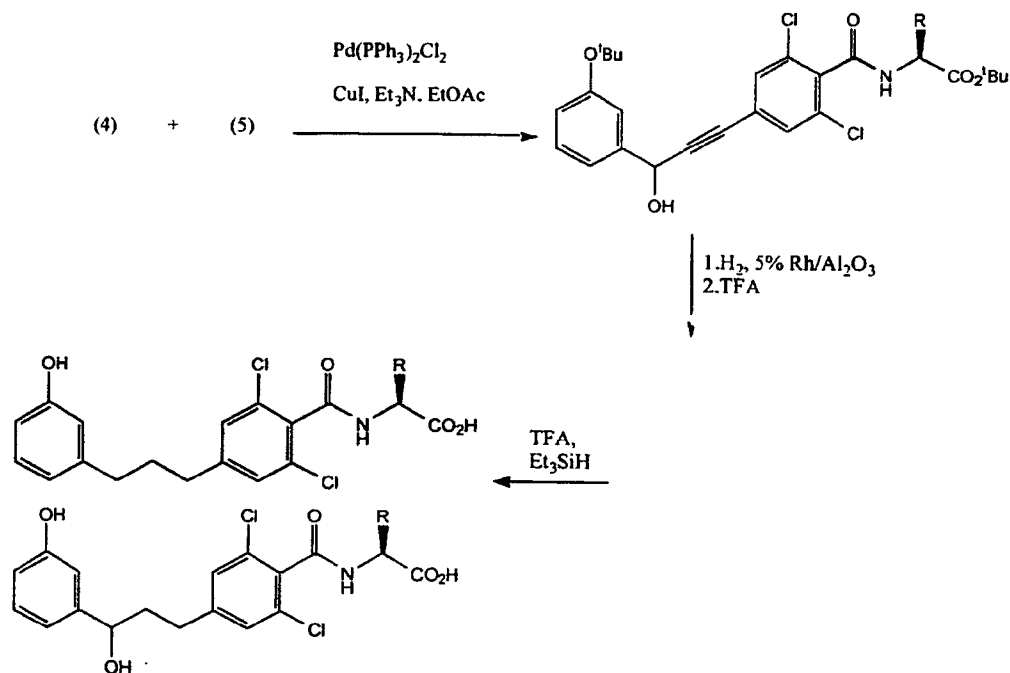
Scheme IIIa



Scheme IV illustrates the synthesis of both substituted or unsubstituted alkane and substituted alkyne linkers.

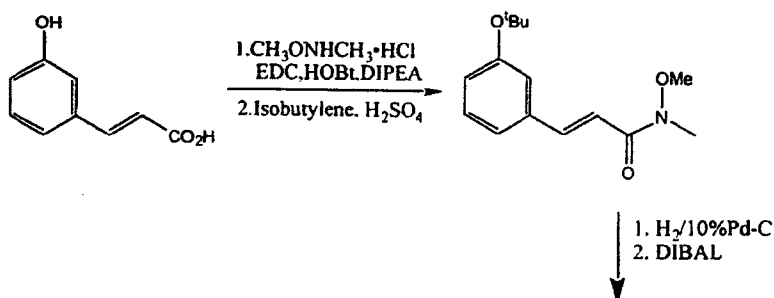
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Scheme IV

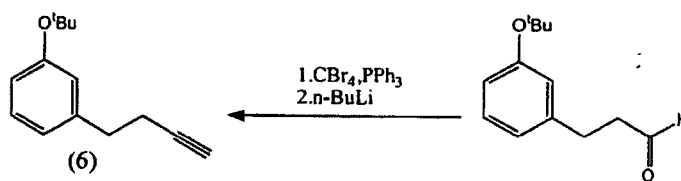


10 A 4 carbon linker can be made by coupling (4) to alkyne intermediate (6) prepared according to Scheme V.

Scheme V

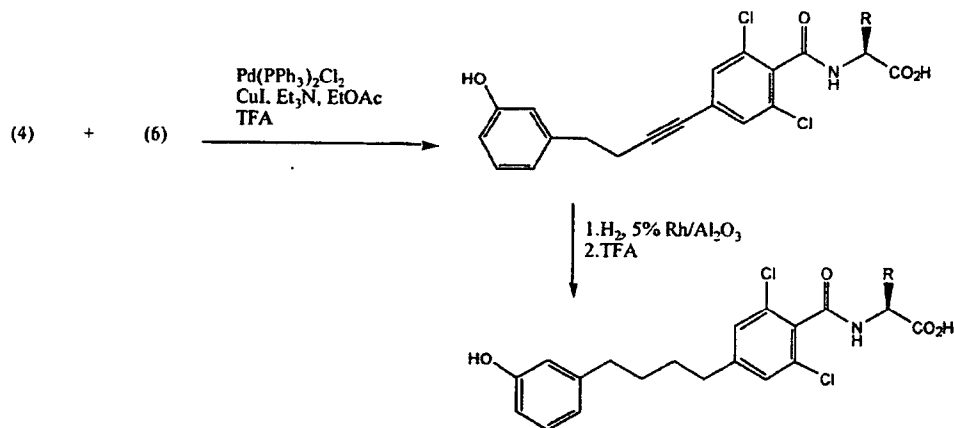






Scheme VI illustrates the synthesis of unsubstituted alkane and alkyne linkers.

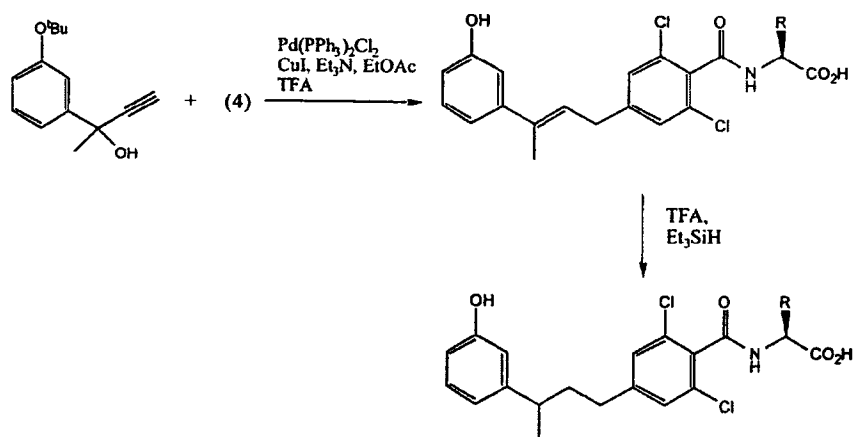
Scheme VI



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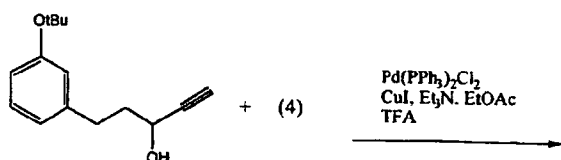
Schemes VIa and VIb illustrate the synthesis of substituted and unsubstituted alkane and alkene linkers of 3-5 carbons long.

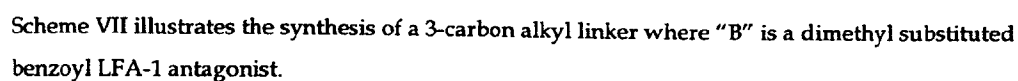
Scheme VIa



10

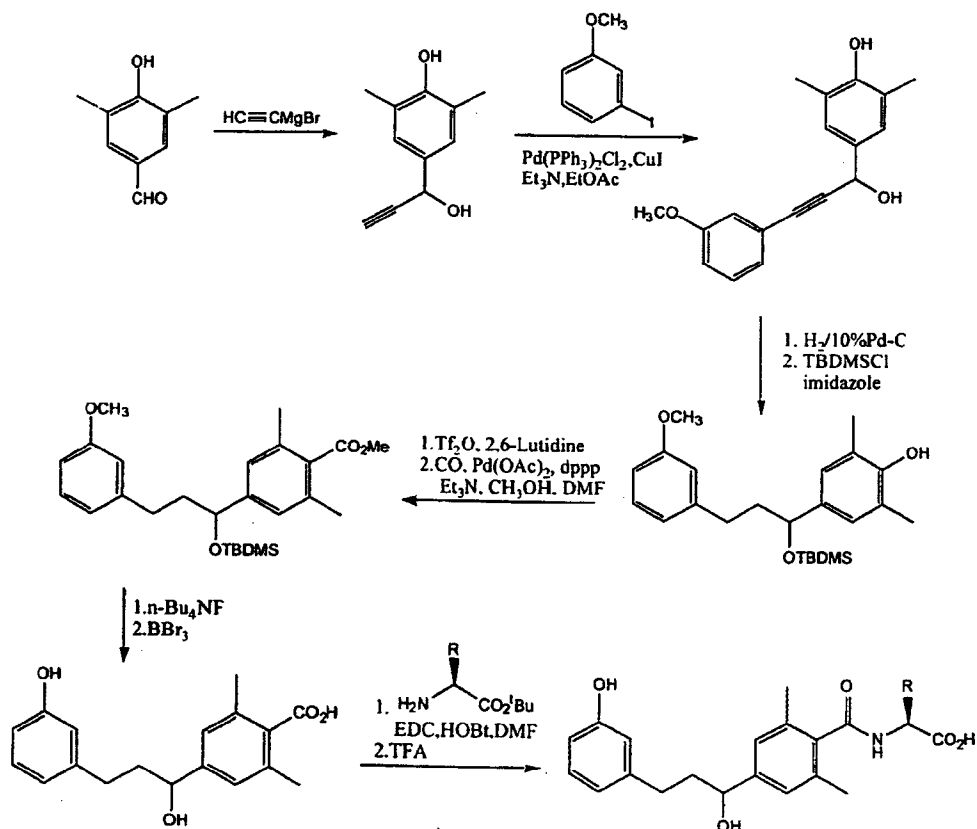
Scheme VIb





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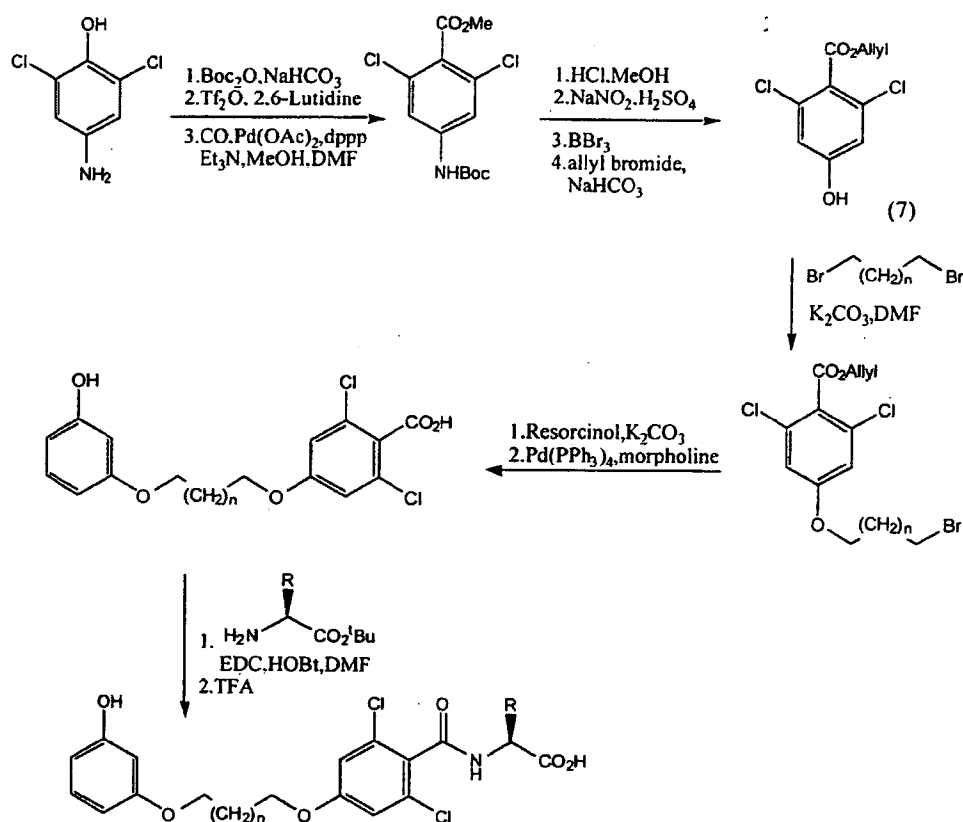
### Scheme VII



10

Scheme VIII illustrates the synthesis of a 3-5 atom diether linker where n is 1-3. Intermediate phenol (7) may also be used in the synthesis of monoethers described below.

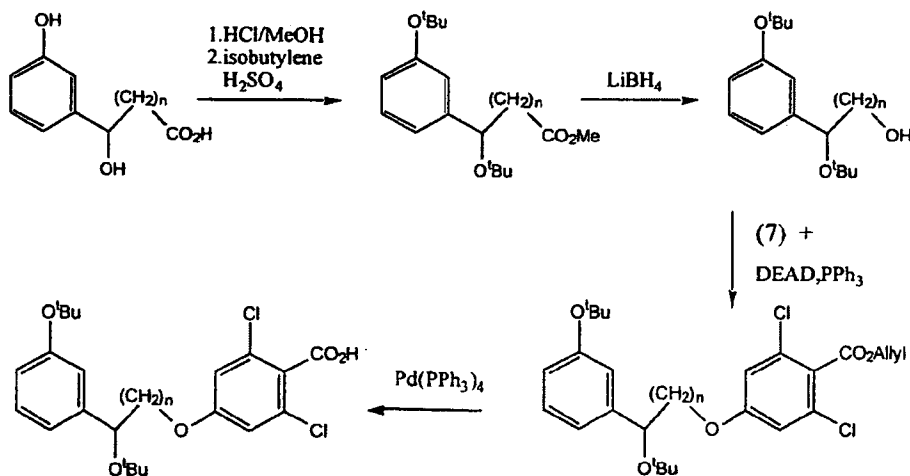
Scheme VIII



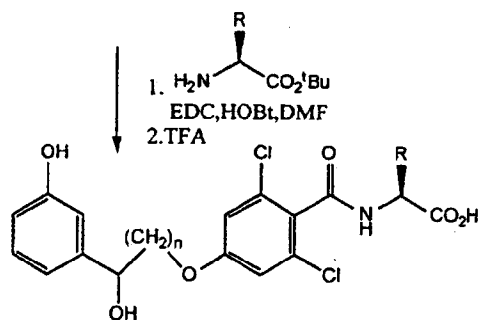
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Scheme IX illustrates the synthesis of a 3-5 atom monoether linkers where  $n$  is 1-3. Intermediate phenol (7) above is employed in this method.

Scheme IX

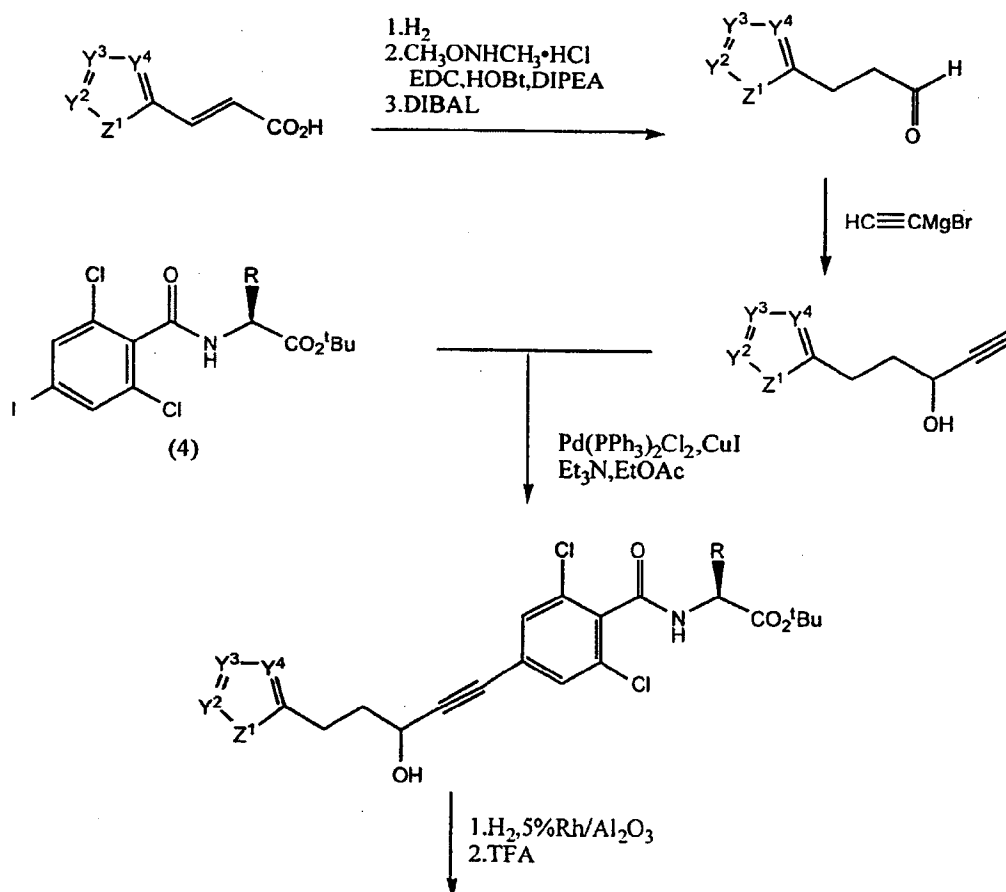


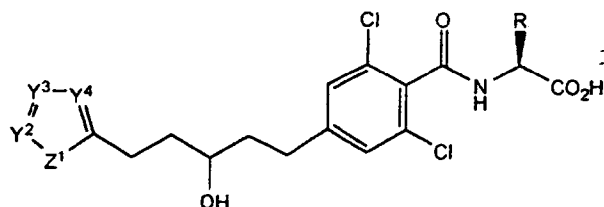
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Scheme X illustrates the synthesis of a 5 atom alkyl linker where the distyl group "D" is a 5-member aromatic ring. Preferred rings include thiophene, furan, thiazole and oxazole, where  $\text{Z}^1$  is O or S and  $\text{Y}^2, \text{Y}^3$  or  $\text{Y}^4$  is selected from N or CH.

Scheme X



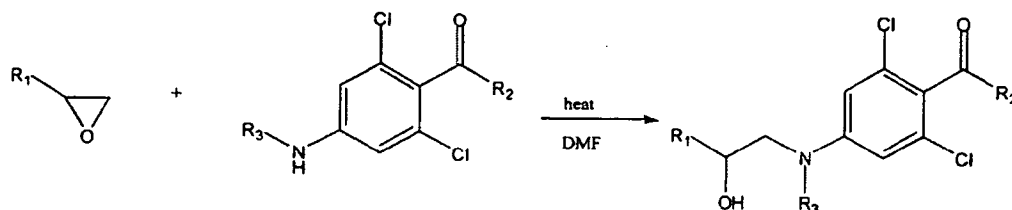


Scheme XI illustrates the synthesis of 3 atom aminoalcohol linkers where the distyl group "D" is phenyl or het.

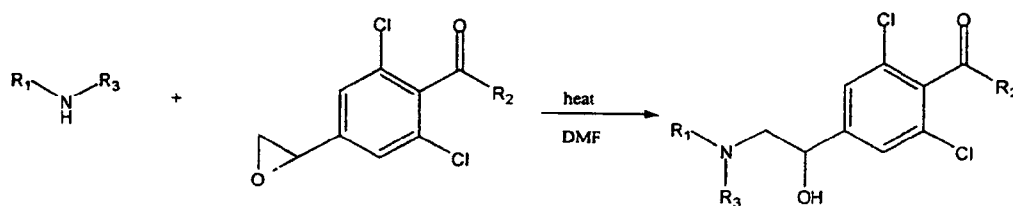
#### Scheme XI

5

Beta hydroxy amines are produced via the reaction of a primary or secondary amine with epoxides. Epoxides are easily prepared by known methods (i.e. oxidation of alkenes).



R1 = phenyl, alkyl, etc.  
R2 = all possible C-termini  
R3 = H or alkyl



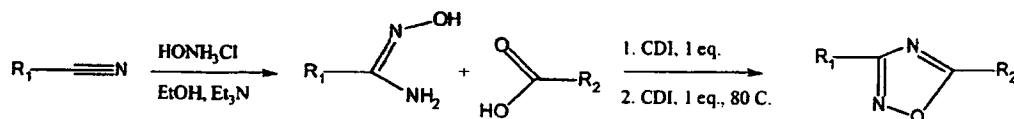
10

Scheme XII illustrates the synthesis of 3-5 atom oxadiazole linkers where the distyl group "D" is phenyl or het.

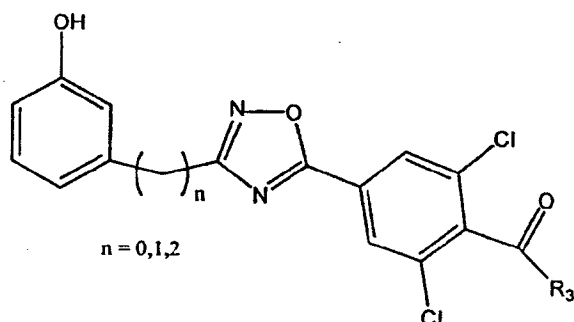
#### Scheme XII

Oxadiazoles are prepared from the combination of hydroxyamidines with an activated carboxylic acid under dehydrating conditions. Hydroxyamidines are conveniently prepared via reaction of a nitrile with hydroxylamine.

15



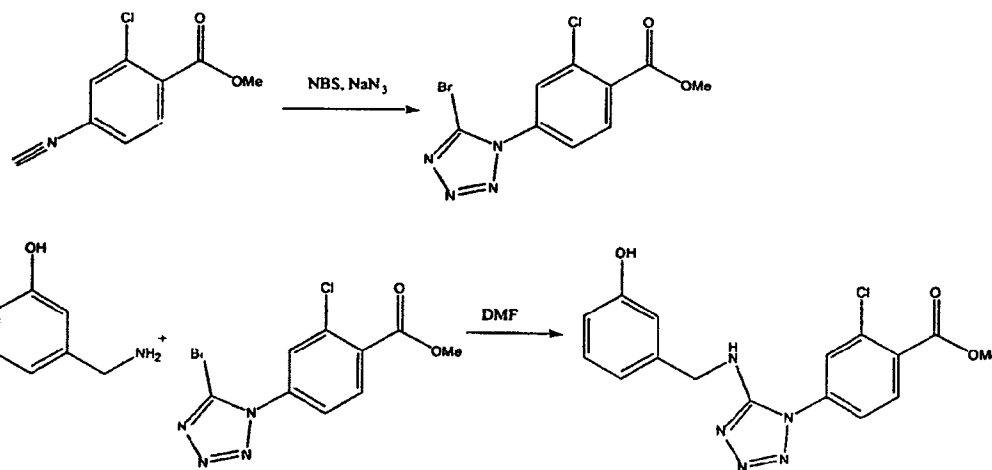
to prepare compounds such as:



Scheme XIII illustrates the synthesis of 5 atom aminotetrazoles linkers where the distyl group "D" is phenyl or het.

#### Scheme XIII

The key step in the preparation of aminotetrazoles is the reaction of a 5-halo-1-phenyltetrazole with an amine. Aminotetrazoles are formed from the reaction of N-bromosuccinimide and sodium azide with phenylisocyanide under phase transfer conditions.



Deprotection and coupling at the carboxylate to add the left side amino acid is carried out as described previously for other compounds.

#### E. Modes for Carrying Out the Invention

Superior immunosuppressive efficacy is seen with a treatment regimen that uses early induction with a high dose of LFA-1 antagonist followed by extended treatment with a lower dose of antagonist.

Typically, the LFA-1 antagonist used in the method of this invention is formulated by mixing it at ambient temperature at the appropriate pH, and at the desired degree of purity, with physiologically acceptable carriers, i.e., carriers that are non-toxic to recipients at the dosages and concentrations employed. The pH of the formulation depends mainly on the particular use and the concentration of antagonist, but preferably ranges anywhere from about 3 to about 8. Formulation in an acetate buffer at pH 5 is a suitable embodiment.

The LFA-1 antagonist for use herein is preferably sterile. LFA-1 antagonist ordinarily will be stored as a solid composition, although lyophilized formulations or aqueous solutions are acceptable.

5 The antagonist composition will be formulated, dosed, and administered in a fashion consistent with good medical practice. Factors for consideration in this context include the particular disorder being treated, the particular mammal being treated, the clinical condition of the individual patient, the cause of the disorder, the site of delivery of the agent, the method of administration, the scheduling of administration, and other factors known to medical practitioners. The "therapeutically effective amount" of LFA-1 antagonist to be administered will be governed by  
10 such considerations, and is the minimum amount necessary to prevent, ameliorate, or treat the LFA-1-mediated disorder, including treating rheumatoid arthritis, multiple sclerosis, asthma, psoriasis (topically or systemically), reducing inflammatory responses, inducing tolerance of immunostimulants, preventing an immune response that would result in rejection of a graft by a host or vice-versa, or prolonging survival of a transplanted graft. Such amount is preferably below  
15 the amount that is toxic to the host or renders the host significantly more susceptible to infections.

As a general proposition, the initial pharmaceutically effective amount of the LFA-1 antagonist administered parenterally per dose will be in the range of about 0.1 to 20 mg/kg of patient body weight per day, with the typical initial range of LFA-1 antagonist used being 0.3 to 15 mg/kg/day.

20 The LFA-1 antagonist is administered by any suitable means, including oral, topical, transdermal, parenteral, subcutaneous, intraperitoneal, intrapulmonary, and intranasal, and, if desired for local immunosuppressive treatment, intralesional administration (including perfusing or otherwise contacting the graft with the antagonist before transplantation). Parenteral infusions include intramuscular, intravenous, intraarterial, intraperitoneal, or subcutaneous administration.  
25 A preferred administration method for psoriasis is topical in close proximity to the affected area.

The LFA-1 antagonist need not be, but is optionally formulated with one or more agents currently used to prevent or treat the disorder in question. For example, in rheumatoid arthritis, the LFA-1 antagonist may be given in conjunction with a glucocorticosteroid. In addition, T-cell receptor peptide therapy is suitably an adjunct therapy to prevent clinical signs of autoimmune encephalomyelitis (*Offner et al., supra.*). For transplants, the LFA-1 antagonist may be  
30 administered concurrently with or separate from an immunosuppressive agent as defined above, e.g., cyclosporin A, to modulate the immunosuppressant effect. The effective amount of such other agents depends on the amount of LFA-1 antagonist present in the formulation, the type of disorder or treatment, and other factors discussed above.

35 The various autoimmune disorders described above are treated with LFA-1 antagonists in such a fashion as to induce immune tolerance to the self antigen under attack as a result of the disorder. In this regard, autoimmune disorders resemble host versus graft rejection and are treated with LFA-1 antagonists in analogous fashion. However, in these disorders the patient is

already mounting an immune response to the target antigen, unlike the case with transplants prior to grafting. Thus, it is desirable to first induce and maintain a transient state of immunosuppression by conventional methods in such patients, e.g. by the conventional use of cyclosporin A or other conventional immunosuppressive agents (alone or together with LFA-1 antagonist), or to monitor the patient until the occurrence of a period of remission (an absence or substantial lessening of pathological or functional indicia of the autoimmune response).

The invention will be more fully understood by reference to the following examples. They should not, however, be construed as limiting the scope of the invention. All literature citations are incorporated by reference.

## Examples

### Example 1

#### Preparation and Purification of full-length LFA-1 from 293 Cells

##### *Construction of LFA-1 cDNA expression vector*

A plasmid with both the human CD11a ( $\alpha_L$ ) and CD18 ( $\beta_2$ ) sequences, each with a separate CMV promoter for expression in 293 cells, was constructed as follows. The plasmid, pRKCD18, containing the full length CD18 cDNA, was cut with restriction enzymes HpaI and Avr II. The plasmid, pRKCD11a, containing the full length CD11a cDNA, was treated with the enzyme Taq I methylase to methylate one of the two Xmn I sites, then cut with Xmn I and Spe I. The fragment from the pRKCD18 digest containing the CD18 coding sequence, the CMV promoter, the antibiotic resistance gene and other plasmid sequences was ligated to the fragment from the pRKCD11a digest containing the CD11a coding sequence and the CMV promoter. The Spe I and Avr II sticky ends are compatible and were ligated together. The Hpa I and Xmn I ends are both blunt and were ligated together to generate the pRK LFA a+b plasmid.

##### *Generation of LFA-1 expressing 293 cell line*

A cell line expressing human LFA-1 was generated by cotransfecting 293 cells with a plasmid (pRK LFA a+b) containing the full-length cDNAs for the  $\alpha_L$  (CD11a) and  $\beta_2$  (CD18) subunits together with pRSVneo, which encodes the G418 resistance marker under the control of the RSV promoter, using previously described methods. (Bodary, Napier and McLean, J Biol. Chem, 264, 32, 18859-18862, 1989) Upon growth in the presence of 0.8mg/ml of G418 for 20 days a population of drug resistant cells was selected for LFA-1 expression, using two color FACS (fluorescence activated cell sorting,) with monoclonal antibodies directed against the  $\alpha_L$  subunit (Fluorescein isothiocyanate labeled monoclonal antibody clone 25.3, catalogue # 0860, AMAC, Inc.) or the  $\beta_2$  subunit-complex (Phycoerythrin labeled MHM23.) (MHM23 antibody reference: Hildreth JEK, and August JT, J Immunol, 134, 3272-3280, 1985) After three rounds of FACS a clonal population was isolated (clone 19) and receptor number was determined to be approximately 106 LFA-1 per cell by Scatchard analysis. This cell line was grown under serum free suspension culture conditions to generate cell pellets for the purification of LFA-1.

*Cell Extraction* (All procedures are at 0-4 °C.)



The frozen 293 cell pellet was suspended in 5 volumes of 0.3 M sucrose/20 mM HEPES/5 mM CaCl<sub>2</sub>/5 mM MgCl<sub>2</sub>/2 mg/ml aprotinin pH 7.4 using a Polytron homogenizer (Brinkman) at approximately 8000 rpm. Once a uniform suspension was obtained, the cells were homogenized at approximately 20,000 rpm for 1 min. Phenylmethane sulfonyl fluoride (PMSF, 100 mM in isopropanol) was then added to the homogenate to a final concentration of 1 mM, and the homogenate was centrifuged at 21,000 x g for 40 min. The supernatant was discarded and the pellet suspended in a volume of 1% Triton X-100 (ultrapure)/0.15 M NaCl/20 mM HEPES/5 mM CaCl<sub>2</sub>/5 mM MgCl<sub>2</sub>/20 mg/ml aprotinin/1 mM PMSF pH 7.4 equal to the volume of sucrose buffer above. The cells were homogenized briefly at about 8000 rpm with the Polytron then placed on a rocker for 30 min. The extract was centrifuged as above and the supernatant saved.

#### Lentil Lectin Column

Approximately 3 to 4 column volumes of cell extract were loaded at 15 cm/hr onto a lentil lectin Sepharose column (Pharmacia) equilibrated in 0.1% Triton X-100/0.15 M NaCl/20 mM HEPES/5 mM CaCl<sub>2</sub>/5 mM MgCl<sub>2</sub> pH 7.4. Once the sample was loaded, the column was washed with equilibration buffer until the A<sub>280</sub> nm reached baseline. LFA-1 was eluted with 0.5 M α-methyl mannoside in equilibration buffer. To maximize recovery, elution was stopped when the LFA-1 started to appear, the column was left overnight in elution buffer then elution was resumed.

#### Q Sepharose Column

The lentil eluate was diluted with an equal volume of 0.1% Triton X-100/20 mM HEPES/5 mM CaCl<sub>2</sub>/5 mM MgCl<sub>2</sub> pH 7.4 and loaded at 15 cm/hr onto a Q Sepharose High Performance column (Pharmacia) equilibrated in the same buffer. After the sample was loaded, the column was washed with equilibration buffer until the A<sub>280</sub> nm approached baseline, then with 1% octyl glucoside/20 mM HEPES/5 mM CaCl<sub>2</sub>/5 mM MgCl<sub>2</sub> pH 7.4 until the Triton X-100 was removed. The LFA-1 was eluted with a 10 column volume 0 to 0.3 M NaCl gradient in the same buffer. Fractions were analyzed by SDS PAGE and the peak fractions pooled and stored frozen at -70 °C.

### Example 2

#### ICAM-1-immunoadhesin

##### *Plasmid for expression of a human ICAM-1-immunoadhesin*

A plasmid for the expression of a human ICAM-1 immunoadhesin was constructed and named pRK5dICAMGaIg. This plasmid contains; a CMV (cytomegalovirus) promoter and enhancer region, an SP6 promoter for making riboprobes, the five immunoglobulin-like domains of ICAM-1, a six amino acid cleavage site recognized by Genenase (a genetically engineered form of subtilisin), the Fc region from human IgG, an SV40 early polyadenylation site, an SV40 origin of replication, a bacterial origin of replication, and a bacterial gene coding for ampicillin resistance.

This plasmid was constructed using fragments from two other plasmids. The first plasmid, pRKICAMm.2, is a plasmid for the expression of full-length ICAM-1. The following two primers were used to generate a fragment containing the five immunoglobulin-like domains of ICAM-1 by

PCR : 1) a 17bp forward primer which is homologous to a portion of the vector sequence 5' of the ICAM-1 coding sequence -5' TGC CTT TCT CTC CAC AG 3' and 2) a 48bp reverse primer which is homologous to 7 amino acids at the 3' end of Ig-like domain 5 and contains sequence coding for a protease cleavage site - 5' GG TGG GCA CAG AGT GTA GTG CGC AGC CTC ATA CCG GGG GGA GAG CAC A 3'. The PCR reaction used 0.2µg of pRKICAMm.2, 1 µl forward primer, at 10 OD/ml, 2µl reverse primer, at 10 OD/ml, 0.2 mM each dATP, dCTP, dGTP, and dTTP, 0.5 mM additional MgCl<sub>2</sub>, 1x VENT polymerase buffer (New England Biolabs), and 1 µl VENT polymerase, at 2 units/µl (New England Biolabs). The reaction was denatured at 98° C for 5' then cycled 20 times through the following temperatures: 98° C 1", 98° C 10", 60° C 1", 60° C 1', 72° C 1", 72° C 1'.

The reaction was extended for 20' at 72°C before being held at 4° C overnight. This reaction produces a 1579bp fragment which was purified using Qiaquick-spin PCR purification kit (Qiagen) and digested with restriction enzymes ClaI and DraIII (New England Biolabs). The resulting 1515bp fragment was gel purified on a 5% acrylamide gel in 1x TBE, electroeluted in 0.1x TBE, and purified on SpinBind columns (FMC). This insert fragment contains the first 5 immunoglobulin domains of ICAM-1 and the Genenase cleavage site.

The second plasmid, trkcfgen, is a plasmid for the expression of the TrkC immunoadhesin containing the same protease cleavage site. This plasmid was digested with: ClaI (New England Biolabs) completely. This material was then digested with DraIII (New England Biolabs) using sub optimal amounts of the enzyme such that a series of partially cut fragments was generated. The desired 5378bp fragment was isolated on a 0.6% GTG Agarose (FMC) gel run in 1x TBE (BRL) and electroeluted in 0.1X TBE. The material was extracted first with butanol, then phenol, then chloroform and precipitated with 0.1 volume 3M NaAcetate, pH 7.0 and 2.5 volumes of EtOH. This vector fragment contains all of the plasmid features listed above except the first 5 immunoglobulin domains of ICAM-1 and the protease cleavage site.

The two fragments described above were combined in an insert:vector ratio of 3:1 using approximately 50 ng of vector in 1x ligase buffer and 2 µl ligase at 400 units/µl (New England Biolabs) for 2 hrs. at room temperature. Half of the reaction was transformed into MM294 competent cells by standard methods.

#### *Generation of ICAM-1-immunoadhesin expressing 293 cell line*

A cell line expressing the ICAM-1-immunoadhesin was generated by transfecting 293 cells with a cDNA encoding the five immunoglobulin domains of human ICAM-1 upstream from the human Fc sequence (pRK.5dICAMGaIg.) together with pRSVneo, as previously described for the LFA-1 cell line. Upon selection in 0.8mg/ml G418 individual clones of drug resistant cells were isolated. Culture supernatants from these clones were assayed for expression of the human ICAM-1-immunoadhesin by ELISA, using polyclonal antibodies directed against the human Fc (Caltag catalogue # H10507, H10700.) A clonal cell line expressing approximately 1mg/ml of ICAM-1-immunoadhesin, as measured by Fc ELISA, was found to react with a monoclonal antibody (AMAC clone 84H10, catalogue # 0544) directed against human ICAM-1. This cell line was grown under

serum free culture conditions and culture supernatant was harvested for purification of the ICAM-1-immunoadhesin.

### Example 3

#### ICAM-1:LFA-1 Receptor Binding Assay

##### (protein/protein assay)

A cartoon illustrating the forward format of the human ICAM-1:LFA-1 Receptor Binding Assay (PPFF) is provided in Figure 2. Competitive inhibition of the CD11a/CD18-ICAM-1 interaction is quantitated by adding known amounts of inhibitors according to the two protein/protein assay systems described below.

##### Forward Format LFA-1:ICAM-1 Assay (PPFF):

Purified full-length recombinant human LFA-1 protein is diluted to 2.5µg/ml in 0.02M Hepes, 0.15M NaCl, and 1mM MnCl<sub>2</sub> and 96-well plates (50µl/well) are coated overnight at 4°C. The plates are washed with wash buffer (0.05% Tween 20 in PBS) and blocked for 1h at room temperature with 1% BSA in 0.02M Hepes, 0.15M NaCl, and 1mM MnCl<sub>2</sub>. Plates are washed. 50µl/well inhibitors, appropriately diluted in assay buffer (0.5% BSA in 0.02M Hepes, 0.15M NaCl, and 1mM MnCl<sub>2</sub>), are added to a 2X final concentration and incubated for 1h at room temperature. 50µl/well of purified recombinant human 5 domain ICAM-Ig, diluted to 50ng/ml in assay buffer, is added and incubated 2h at room temperature. Plates are washed and bound ICAM-Ig is detected with Goat anti-HuIgG(Fc)-HRP for 1h at room temperature. Plates are washed and developed with 100µl/well TMB substrate for 10-30' at room temperature. Colorimetric development is stopped with 100µl/well 1M H<sub>3</sub>PO<sub>4</sub> and read at 450nm on a platereader.

An alternative protein/protein assay system described below also quantitates competitive inhibition of the CD11a/CD18-ICAM-1 interaction.

##### PLM2 Antibody Capture LFA-1:ICAM-1 Assay (PLM2):

A non-function blocking monoclonal antibody against human CD18, PLM-2 (as described by Hildreth, *et al.*, *Molecular Immunology*, Vol. 26, No. 9, pp. 883-895, 1989), is diluted to 5µg/ml in PBS and 96-well flat-bottomed plates are coated with 100µl/well overnight at 4°C. The plates are blocked with 0.5% BSA in assay buffer (0.02M Hepes, 0.15M NaCl, and 1mM MnCl<sub>2</sub>) 1h at room temperature. Plates are washed with 50mM Tris pH 7.5, 0.1M NaCl, 0.05% Tween 20 and 1mM MnCl<sub>2</sub>. Purified full-length recombinant human LFA-1 protein is diluted to 2µg/ml in assay buffer and 100µl/well is added to plates and incubated 1h at 37°C. Plates are washed 3X. 50µl/well inhibitors, appropriately diluted in assay buffer, are added to a 2X final concentration and incubated for 30' at 37°C. 50µl/well of purified recombinant human 5 domain ICAM-Ig, diluted to 161ng/ml (for a final concentration of 80ng/ml) in assay buffer, is added and incubated 2h at 37°C. Plates are washed and bound ICAM-Ig is detected with Goat anti-HuIgG(Fc)-HRP for 1h at room temperature. Plates are washed and developed with 100µl/well TMB substrate for 5-10' at room

temperature. Colorimetric development is stopped with 100µl/well 1M H<sub>3</sub>PO<sub>4</sub> and read at 450nm on a platereader.

#### Example 4

##### Human T-cell Adhesion Assay

##### (cell attachment assay)

5 A cartoon illustrating the human T cell adhesion colorimetric assay is provided in Figure 3. The T-cell adhesion assay is performed using a human T-lymphoid cell line HuT 78. Goat anti-HuIgG(Fc) was diluted to 2µg/ml in PBS and 96-well plates were coated with 50µl/well @ 37°C for 1h. Plates were washed with PBS and blocked for 1h @ room temperature with 1% BSA in PBS. 10 domain ICAM-Ig was diluted to 100ng/ml in PBS and 50µl/well was added to the plates O/N @ 4°C. HuT 78 cells were centrifuged at 100 g and the cell pellet was treated with 5mM EDTA for ~5' at 37°C in a 5% CO<sub>2</sub> incubator. Cells were washed in 0.14M NaCl, 0.02M Hepes, 0.2% Glucose and 0.1mM MnCl<sub>2</sub> (assay buffer) and centrifuged. The cells were resuspended in assay buffer to 3.0 x 10<sup>6</sup>/ml. Inhibitors were diluted in assay buffer to a 2X final concentration and pre-incubated with 15 HuT 78 cells for 30' at room temperature. 100µl/well of cells and inhibitors were added to the plates and incubated at room temperature for 1h. 100µl/well PBS was added and the plates were sealed and centrifuged inverted at 100 g for 5'. Unattached cells were flicked out of the plate and excess PBS was blotted on a paper towel. 60µl/well *p*-nitrophenyl *n*-acetyl-β-D-glucosaminide (0.257g to 100ml citrate buffer) was added to the plate and incubated for 1.5h at 37°C. The enzyme 20 reaction was stopped with 90µl/well 50mM Glycine/5mM EDTA and read on a platereader at 405nm. HUT 78 cell adhesion to 5dICAM-Ig is measured using the *p*-nitrophenyl *n*-acetyl-β-D-glucosaminide method of Landegren, U. (1984) *J. Immunol. Methods* 57, 379-388

#### Example 5

##### T-Cell Proliferation assay (co-stimulation assay)

25 A cartoon illustrating the human T cell proliferation assay is provided in Figure 4. This assay is an in vitro model of lymphocyte proliferation resulting from activation, induced by engagement of the T-cell receptor and LFA-1, upon interaction with antigen presenting cells (Springer, *Nature* 346:425 (1990)).

30 Microtiter plates (Nunc 96 well ELISA certified) were precoated overnight at 4°C with 50µl of 2µg/ml of goat anti-human Fc (Caltag H10700) and 50µl of 0.07µg/ml monoclonal antibody to CD3 (Immunotech 0178) in sterile PBS. The next day coat solutions were aspirated. Plates were then washed twice with PBS and 100µl of 17 ng/ml 5d-ICAM-1-IgG were added for 4 hours at 37°C. Plates were washed twice with PBS prior to addition of CD4<sup>+</sup> T cells. Lymphocytes from peripheral 35 blood were separated from heparinized whole blood drawn from healthy donors. An alternative method was to obtain whole blood from healthy donors through leukopheresis. Blood was diluted 1:1 with saline, layered, and centrifuged at 2500 x g for 30 minutes on LSM (6.2g Ficoll and 9.4g

sodium dithiozate per 100ml) (Organon Technica, NJ). Monocytes were depleted using a myeloid cell depletion reagent method (Myeloclear, Cedarlane Labs, Hornby, Ontario, Canada). PBLs were resuspended in 90% heat-inactivated Fetal Bovine serum and 10% DMSO, aliquoted, and stored in liquid nitrogen. After thawing, cells were resuspended in RPMI 1640 medium (Gibco, Grand island, NY) supplemented with 10% heat-inactivated Fetal Bovine serum (Intergen, Purchase, NY), 1mM sodium pyruvate, 3mM L-glutamine, 1mM nonessential amino acids, 500µg/ml penicillin, 50µg/ml streptomycin, 50µg/ml gentamycin (Gibco).

Purification of CD4+ T cells were obtained by a negative selection method (Human CD4 Cell Recovery Column Kit #CL110-5 Accurate). 100,000 purified CD4+ T cells (90% purity) per microtiter plate well were cultured for 72 hours at 37°C in 5% CO<sub>2</sub> in 100µl of culture medium (RPMI 1640 (Gibco) supplemented with 10% heat inactivated FBS (Intergen), 0.1mM non-essential amino acids, 1mM Sodium Pyruvate, 100 units/ml Penicillin, 100 µg/ml Streptomycin, 50µg/ml Gentamicin, 10mM Hepes and 2mM Glutamine). Inhibitors were added to the plate at the initiation of culture. Proliferative responses in these cultures were measured by addition of 1µCi/well tritiated thymidine during the last 6 hours before harvesting of cells. Incorporation of radioactive label was measured by liquid scintillation counting (Packard 96 well harvester and counter). Results are expressed in counts per minute (cpm).

#### Example 6

##### *In vitro* Mixed Lymphocyte Culture Model

A cartoon depicting the mixed lymphocyte response assay is provided in Figure 5. This mixed lymphocyte culture model, which is an *in vitro* model of transplantation (A.J. Cunningham, "Understanding Immunology, *Transplantation Immunology* pages 157-159 (1978), examines the effects of various LFA-1 antagonists in both the proliferative and effector arms of the human mixed lymphocyte response.

**Isolation of Cells:** Mononuclear cells from peripheral blood (PBMC) were separated from heparinized whole blood drawn from healthy donors. Blood was diluted 1:1 with saline, layered, and centrifuged at 2500 x g for 30 minutes on LSM (6.2g Ficoll and 9.4g sodium dithiozate per 100ml) (Organon Technica, NJ). An alternative method was to obtain whole blood from healthy donors through leukapheresis. PBMCs were separated as above, resuspended in 90% heat-inactivated Fetal Bovine serum and 10% DMSO, aliquoted, and stored in liquid nitrogen. After thawing, cells were resuspended in RPMI 1640 medium (Gibco, Grand Island, NY) supplemented with 10% heat-inactivated Fetal Bovine serum (Intergen, Purchase, NY), 1mM sodium pyruvate, 3mM L-glutamine, 1mM nonessential amino acids, 500µg/ml penicillin, 50µg/ml streptomycin, 50µg/ml gentamycin (Gibco).

**Mixed Lymphocyte Response (MLR):** One way human mixed lymphocyte cultures were established in 96-well flat-bottomed microtiter plates. Briefly,  $1.5 \times 10^5$  responder PBMCs were co-cultured with an equal number of allogeneic irradiated (3000 rads for 3 minutes, 52 seconds)

stimulator PBMCs in 200µl of complete medium. LFA-1 antagonists were added at the initiation of cultures. Cultures were incubated at 37°C in 5% CO<sub>2</sub> for 6 days, then pulsed with 1µCi/well of <sup>3</sup>H-thymidine (6.7 Ci/mmol, NEN, Boston, MA) for 6 hours. Cultures were harvested on a Packard cell harvester (Packard, Canberra, Canada). [<sup>3</sup>H] TdR incorporation was measured by liquid scintillation counting. Results are expressed as counts per minute (cpm).

#### Example 7

##### Compound Synthesis and Activity

Abbreviations used in the following section: Wang resin = p- alkoxybenzyl alcohol resin; Fmoc = 9- fluorenylmethyloxycarbonyl; Fmoc-OSu = 9- fluorenylmethyloxycarbonyl- N-hydroxysuccinimide; Boc = t- butyloxycarbonyl; Boc<sub>2</sub>O = t- butyloxycarbonyl anhydride; DMA = dimethylacetamide; DMF = dimethylformamide; BOP = (benzotriazol-1-yloxy) tris (dimethyl-amino) phosphonium hexafluorophosphate; Hobt = 1-hydroxybenzotriazole; NMM = 4-methylmorpholine; TFA = trifluoroacetic acid; DCM = dichloromethane; MeOH = methanol; HOAc = acetic acid; HCl = hydrochloric acid; H<sub>2</sub>SO<sub>4</sub> = sulfuric acid; K<sub>2</sub>CO<sub>3</sub> = potassium carbonate; Ph<sub>3</sub>P = triphenylphosphine; THF = tetrahydrofuran; EtOAc = ethyl acetate; DIPEA = diisopropylethylamine; NaHCO<sub>3</sub> = sodium bicarbonate; NMP = N-methyl pyrrolidinone; DIPC = diisopropylcarbodiimide; ACN = acetonitrile; HBTU = 2-(1H-benzotriazole-1-yl)-1, 1, 3, 3-tetramethyluronium hexafluorophosphate; NCS = N-chlorosuccinimide; Na<sub>2</sub>•EDTA = ethylenediaminetetraacetic acid sodium salt; TBAF = tetrabutyl ammonium fluoride; EDC = 1-(3-dimethylaminopropyl)-3-ethylcarbodiimide•HCl; DEAD = diethyl azocarboxylate; TEA = triethylamine; MgSO<sub>4</sub> = magnesium sulfate; TES = triethylsilane; Et<sub>2</sub>O = diethyl ether; BBr<sub>3</sub> = boron tribromide

##### General synthetic methods

##### Method G1

The appropriate Boc protected molecule was dissolved in a solution of TFA in DCM (1:1). After 20 minutes, the reaction was concentrated *in vacuo*. The resulting oil was dissolved in toluene and then concentrated *in vacuo* twice.

##### Method G2

The appropriate amine was dissolved in Et<sub>2</sub>O and washed twice with a 10% solution of K<sub>2</sub>CO<sub>3</sub> in H<sub>2</sub>O and once with brine. The organic layer was then dried over MgSO<sub>4</sub>, filtered and concentrated *in vacuo*. The product was then used with out further purification.

##### Method G3

3 equivalents of the appropriate carboxylic acid was coupled to 1 equivalent of the appropriate amine using 3 equivalents EDC and 1 equivalent of Hobt in DMA. The reaction was monitored by TLC (9/1 DCM/MeOH). Upon completion, the mixture was concentrated *in vacuo*. The resulting oil was re suspended in Et<sub>2</sub>O and washed twice with 0.1 N H<sub>2</sub>SO<sub>4</sub>, twice with saturated NaHCO<sub>3</sub>, and once with brine. The organic layer was then dried over MgSO<sub>4</sub>, filtered and concentrated *in vacuo*. The product was then used with out further purification.

**Method G4**

1 equivalent of the appropriate methyl ester was dissolved in THF/H<sub>2</sub>O (3/1) and 3 equivalents of LiOH·H<sub>2</sub>O was added. The reaction was monitored by TLC (9/1 DCM/MeOH). Upon completion, the mixture was acidified carefully to pH 2 with concentrated HCl and then concentrated *in vacuo*. The resulting solid was re suspended in Et<sub>2</sub>O and washed twice with 0.1 N H<sub>2</sub>SO<sub>4</sub> and once with brine. The organic layer was then dried over MgSO<sub>4</sub>, filtered and concentrated *in vacuo*.

**Method G5**

1 equivalent of the appropriate amino acid and 2.5 equivalents of NaHCO<sub>3</sub> were dissolved in THF/H<sub>2</sub>O (3/1). Once the solution becomes clear, 1.5 equivalents of Fmoc-OSu was added. The reaction was monitored by TLC (9/1 DCM/MeOH). Upon completion, the mixture was concentrated *in vacuo* until only the aqueous phase remained. The aqueous solution was then extracted twice with Et<sub>2</sub>O and then acidified carefully to pH 2 with concentrated HCl to precipitate out the product. The aqueous layer and product was then extracted with EtOAc. The organic layer was then partitioned once with brine and dried over MgSO<sub>4</sub>, filtered and concentrated *in vacuo*. The resulting product was used without further purification.

**Method G6**

1 equivalent of fluorenylmethanol and 2.5 equivalents of Hobt was dissolved in NMP. The mixture was cooled to 0°C with stirring. Once cool, 1 equivalent of DIPC was added over 5 minutes with stirring followed by portion wise additions of 1 equivalent of 2- bromoterephthalic acid and then 0.01 equivalents of 4- pyrrolidinopyridine. The mixture was stirred at 0°C for 2 hours, warmed to room temperature and stirred for 4 hours, and then re-cooled to 0°C and quenched with the drop wise addition of H<sub>2</sub>O. After stirring for 1 hour, the mixture was partitioned with EtOAc. The organic layer was then partitioned twice with dilute HCl, once with brine and dried over MgSO<sub>4</sub>, filtered and concentrated *in vacuo*. The crude product (a 9:1 mixture of correct versus incorrect isomer) was purified using flash silica chromatography using 3/1 hexanes/EtOAc and 3% HOAc.

**Method G7**

The appropriate methoxy containing compound was dissolved in DCM and cooled to -5°C in an ice/acetone bath under nitrogen. 2 equivalents of BBr<sub>3</sub> was added drop wise as a solution in DCM over 30 minutes. The reaction was warmed to room temperature and stirred until complete by TLC (DCM/2% HOAc/2% MeOH). The solution was poured onto ice, and the ice was allowed to melt. The mixture was then partitioned twice with EtOAc and the combined organic layers were dried over MgSO<sub>4</sub>. The filtrate was then passed over a plug of silica gel and concentrated *in vacuo*.

**Method G8**

1 equivalent of dimethyl 2- chloroterephthalic acid was mono hydrolyzed by Method G9 to afford the correct mono protected diacid. The mono ester was then *t*- butyl esterified by Method G10. The methyl ester was then removed by Method G4 to yield the carboxylic acid (Compound A).

**Method G9**

The diester was dissolved in DCM and cooled to -5°C in an ice/acetone bath under nitrogen. 1 equivalent of BBr<sub>3</sub> was added drop wise as a solution in DCM over 30 minutes. The reaction was warmed to room temperature and stirred until complete by TLC (DCM/2% HOAc/2% MeOH). The solution was poured onto ice, and the ice was allowed to melt. The mixture was then partitioned with EtOAc and concentrated *in vacuo*. This product was dissolved in H<sub>2</sub>O with the addition of saturated NaHCO<sub>3</sub> until the pH remained above 8. This solution was partitioned one time with an equal volume of DCM to remove unreacted diester. The basic solution was acidified at 0°C. with concentrated HCl to pH = 1-1.5, and precipitate was extracted twice with equal volumes of EtOAc. The organics were partitioned once with brine and dried over MgSO<sub>4</sub>, filtered and concentrated *in vacuo*. Product was 7:1 of the correct regioisomer by HPLC.

**Method G10**

The monoester was dissolved in DCM was transferred to pre-weighed Parr flask containing a stirring bar. The flask was cooled to -5°C with a dry ice/alcohol bath under nitrogen. Once cool, ~30 equivalents of isobutylene was pumped into solution with stirring. 2.1 equivalents of concentrated sulfuric acid was added and the flask was sealed with a wired rubber stopper and allowed to warm to room temperature with stirring. The solution was stirred until clarification (1-2 days). Once the solution was clear, it was cooled to 0°C in an ice bath. The stopper was removed and the excess isobutylene was blown off with nitrogen bubbling. Saturated NaHCO<sub>3</sub> was added to neutralize the acid and the mixture was concentrated *in vacuo* until no DCM remained. The solution was then partitioned into EtOAc. The organics were partitioned twice with dilute HCl, twice with saturated NaHCO<sub>3</sub>, once with brine, dried over MgSO<sub>4</sub>, filtered and concentrated *in vacuo*. The resulting product was used with no further purification.

**Method G11**

The *t*-butyl ester product was dissolved in DCM and an equal volume of TFA was added. After 30 minutes the reaction was concentrated *in vacuo* and twice redissolved and concentrated from toluene. The product was used without further purification.

**Method G12**

Compound A was coupled to 3-chloro benzylamine by Method G3. The *t*-butyl ester was removed by Method G11 to yield the carboxylic acid (Compound B).

**Method G13**

Compound A was coupled to 3-methoxy benzylamine, Method G38, by Method G3. This product was converted to the methyl ester by Method G15. The methoxy group was demethylated to the phenol by Method G7. The methyl ester was saponified to the carboxylic acid by Method G4 and the final product (Compound C) was used without further purification.

**Method G14**

1 equivalent of 4-bromo 2-chloro benzoic acid was converted to the methyl ester by Method G15 and the bromine was converted to the nitrile by Method G16. After saponification by



Method G4, the nitrile was reduced to the amine and Fmoc protected by Method G17. The final product (Compound D) was purified by flash silica chromatography (95/5 DCM/MeOH) and verified by electrospray mass spectrometry.

#### Method G15

5       The appropriate carboxylic acid was dissolved in dry MeOH and 10 equivalents of HCl/dioxane was added and the mixture was stirred overnight to yield the methyl ester product. The solution was concentrated *in vacuo* and twice redissolved and concentrated from toluene. The final product was purified by flash silica chromatography (95/5 DCM/MeOH) and verified by electrospray mass spectrometry.

#### 10    Method G16

0.6 equivalents of Zinc cyanide and 0.04 equivalents of tetrakis(triphenylphosphine) palladium(0) were placed in a round bottom flask and purged for 30 minutes with circulating nitrogen. The methyl ester was dissolved in anhydrous DMF and degassed for 30 minutes with nitrogen. Upon completion of degassing, the methyl ester solution was added to the zinc cyanide and palladium via cannula and stirred over night at 80°C. Upon completion of the reaction, the solution was concentrated *in vacuo* and redissolved in EtOAc. The organics were partitioned twice with dilute HCl, twice with saturated NaHCO<sub>3</sub>, once with brine, dried over MgSO<sub>4</sub>, filtered and concentrated *in vacuo*. The product was purified by flash silica chromatography (DCM) and verified by electrospray mass spectrometry.

#### 20    Method G17

1 equivalent of the nitrile was dissolved in THF and cooled to 0°C in an ice bath. Once cool, 4 equivalents of super hydride was added quickly via cannula to the nitrile. After 5 minutes, the reaction was poured onto ice containing 5 equivalents of sulfuric acid and stirred until all of the ice melts. Two volumes of THF was added to the solution and the pH was carefully adjusted to 8 with portion wise additions of NaHCO<sub>3</sub>. 1.5 equivalents of Fmoc-OSu was added. The reaction was monitored by TLC (9/1 DCM/MeOH). Upon reaction completion, the mixture was concentrated *in vacuo* until only the aqueous phase remained. The aqueous solution was then extracted twice with Et<sub>2</sub>O and then acidified carefully to pH 2 with concentrated HCl to precipitate out the product. The aqueous layer and product was then extracted with EtOAc. The organic layer was then partitioned once with brine and dried over MgSO<sub>4</sub>, filtered and concentrated *in vacuo*.

#### 30    Method G18

1 equivalent of the appropriate hydroxy carboxylic acid, 2.2 equivalents of *tert*-butyldimethyl silyl chloride and 3 equivalents of imidazole were dissolved in DMF and stirred at room temperature. The reaction was monitored by TLC (9/1 DCM/MeOH). Upon reaction completion, the mixture was concentrated *in vacuo*. The resulting oil was re suspended in Et<sub>2</sub>O and washed twice with saturated NaHCO<sub>3</sub>, and once with brine. The organic layer was then dried over MgSO<sub>4</sub>, filtered and concentrated *in vacuo*. The product was then used without further purification.

**Method G19**

To resin that has been rinsed twice with DMA, a solution consisting of 20% piperidine in DMA was added. After 20 minutes, the resin was filtered and rinsed 5 times with DMA.

**Method G20**

- 5        3 equivalents of the appropriate carboxylic acid was coupled with 3 equivalents of BOP, 1 equivalent of HOBt, , and 6 equivalents of NMM in DMA for 30 minutes. The coupling was monitored by the Kaiser ninhydrin test. If the Kaiser test was positive, the appropriate carboxylic acid was coupled again in the same manner.

**Method G21**

- 10       The molecule was cleaved from the rinsed and dried resin in a solution consisting of 5% triisopropylsilane in TFA for 1 hour. The crude molecule was then concentrated *in vacuo*, purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

**Method G22**

- 15       3 equivalents of the appropriate amine was coupled with 3 equivalents of BOP, 1 equivalent of HOBt, , and 6 equivalents of NMM in DMA for 60 minutes.

**Method G23**

- 20       The resin was washed successively with DMA, DCM, 20% HOAc in DCM, MeOH and DMF. 2 equivalents of the appropriate aldehyde was dissolved in a minimal volume of 1% HOAc in DMF and added to the freshly rinsed resin. After 5 minutes, 2 equivalents of sodium cyanoborohydride in DMF was added, and the resin was bubbled overnight. The resin was then washed with DMF, 20% DIPEA in DCM, DCM and MeOH. The coupling was monitored by the Kaiser ninhydrin test. If the Kaiser test was positive, the appropriate aldehyde was coupled again in the same manner.

**Method G24**

- 25       3 equivalents of the appropriate carboxylic acid (R) was coupled with 3 equivalents of HBTU, and 3 equivalents of DIPEA, in DMA. The reaction was followed by TLC. Upon completion, the mixture was diluted with EtOAc. The organic layer was partitioned with dilute sulfuric acid, saturated NaHCO<sub>3</sub>, dried over MgSO<sub>4</sub>, filtered and concentrated *in vacuo*. The resulting methyl ester product was then used with out further purification.

**Method G25**

- 30       The methyl ester of the appropriate carboxylic acid was made by Method G15 and the phenol was converted to the *t*-butyl ester by Method G10. 1 equivalent of the resulting product was dissolved in a 1:2 mixture of THF and EtOH, and 3 equivalents of lithium chloride and 3 equivalents of sodium borohydride was added and the reaction was stirred overnight. The reaction was  
35       quenched with H<sub>2</sub>O and concentrated *in vacuo*. The residue was partitioned between EtOAc and H<sub>2</sub>O, and the aqueous layer was extracted with EtOAc. The combined organic layers were dried over MgSO<sub>4</sub>, filtered and concentrated *in vacuo*. The crude alcohol was purified using silica gel flash chromatography (9:1 hexane/Et<sub>2</sub>O).

**Method G26**

A solution of 1 equivalent of the alcohol and 1.1 equivalents of  $\text{Ph}_3\text{P}$  in THF was cooled to  $-10^\circ\text{C}$  in an ice-ethanol bath. While stirring, a solution of 1.1 equivalents of the phenol and 1.1 equivalents of DEAD in THF was added drop wise. The cold bath was removed and the reaction was stirred at room temperature overnight. The reaction was concentrated *in vacuo* and the resulting residue was taken up in a minimal amount of DCM and filtered through a plug of silica gel, using DCM as eluent. After concentrating this solution *in vacuo*, the residue was purified using silica gel flash chromatography (8/2/0.5 hexane/DCM/ $\text{Et}_2\text{O}$ ) to provide the pure ether.

**Method G27**

1 equivalent of the alcohol was dissolved in acetone and cooled to  $-10^\circ\text{C}$ . 1.1 equivalents of Jones reagent was added and the reaction was stirred at room temperature for 2 hours. The reaction was filtered through a plug of silica gel and concentrated *in vacuo*. The residue was partitioned between EtOAc and  $\text{H}_2\text{O}$ . The residue was partitioned between EtOAc and  $\text{H}_2\text{O}$ , and the aqueous layer was extracted with EtOAc. The combined organic layers were dried over  $\text{MgSO}_4$ , filtered and concentrated *in vacuo*. The yellow solid was triturated with  $\text{Et}_2\text{O}$  to remove impurities, providing pure ketone.

**Method G28**

1 equivalent of the appropriate dihydroxynaphthalene was dissolved in pyridine. 4 equivalents of solid sodium hydride was added followed by 2 equivalents of the bromide and 0.4 equivalents of cuprous chloride. The resulting mixture was stirred vigorously and heated in an oil bath at  $100^\circ\text{C}$  for two days. After concentrating *in vacuo*, the residue was partitioned between EtOAc and 1M HCl. The aqueous layer was extracted with EtOAc. The combined organic layers were dried over  $\text{MgSO}_4$ , filtered and concentrated *in vacuo*. The residue was triturated with  $\text{Et}_2\text{O}$ . After filtering the mixture and concentrating the filtrate, the resulting residue was purified using silica gel flash chromatography (5:4:1 hexane/DCM/ $\text{Et}_2\text{O}$ ).

**Method G29**

To a stirred  $-78^\circ\text{C}$  solution of 1 equivalent of the appropriate methyl ester in dry toluene was added a solution of 1.5 M DIBAL in toluene (1.7 equivalents) drop wise. The reaction mixture was stirred for an additional 2 hours at  $-78^\circ\text{C}$  or until TLC showed clean formation of product, with only a trace of starting material. The reaction was quenched by slowly adding cold ( $-78^\circ\text{C}$ ) MeOH. The resulting white emulsion was slowly poured into ice-cold 1 N HCl and EtOAc and the aqueous layer was extracted with EtOAc. The combined organic layers were dried over  $\text{MgSO}_4$ , filtered and concentrated *in vacuo*. The residue was purified using silica gel flash chromatography (9:1 hexane/ $\text{Et}_2\text{O}$ ) to provide the pure aldehyde.

**Method G30**

1 equivalent of the amido alcohol made by Method G28 and 1.5 equivalents of  $\text{Ph}_3\text{P}$  were dissolved in THF and cooled to  $-5^\circ\text{C}$ . 1.5 equivalents of DEAD was added drop wise and the reaction was stirred at room temperature overnight. After concentrating the reaction *in vacuo*, the

residue was taken up in a minimal amount of DCM and purified by flash chromatography (9:1 hexane/Et<sub>2</sub>O) to provide pure oxazoline.

#### Method G31

To a stirred -78°C solution of 1 equivalent of the bromide in THF was added 1.6 M n-BuLi (1.05 equivalents) drop wise. After 0.5 hour, 1.1 equivalents of the aldehyde in THF was added via cannula at -78°C and the reaction was stirred at -78°C. After 2 hours, the reaction was quenched with 2 equivalents cold (-78°C) HOAc in THF. The mixture was warmed to room temperature, concentrated *in vacuo*, and the oily residue partitioned between Et<sub>2</sub>O and H<sub>2</sub>O. The aqueous layer was extracted with Et<sub>2</sub>O. The combined organic layers were dried over MgSO<sub>4</sub>, filtered and concentrated *in vacuo*. The residue was purified using silica gel flash chromatography (7:3 hexane/Et<sub>2</sub>O).

#### Method G32

The oxazoline alcohol was dissolved in a 13:1 mixture of ethanol and sulfuric acid, then heated at reflux for 3 days. The reaction was concentrated *in vacuo*, and the residue was partitioned between Et<sub>2</sub>O and H<sub>2</sub>O. The aqueous layer was extracted with Et<sub>2</sub>O. The combined organic layers were dried over MgSO<sub>4</sub>, filtered and concentrated *in vacuo*. The residue was purified using silica gel flash chromatography (1:1 hexane/Et<sub>2</sub>O) to give the pure ethyl ester.

#### Method G33

To freshly rinsed resin was added, 2.2 equivalents of DIPEA and 2.2 equivalents of the appropriate isocyanate (R) in 1, 2- dichloroethane were added and the resin agitated overnight. The resin was then washed with 10% piperidine in NMP, THF, 30% HOAc in DCM and MeOH.

#### Method G34

1 equivalent of 4- benzyloxy benzyl alcohol resin (Wang resin) was washed with DMA and DCM. To the resin was added 3 equivalents of the appropriate Fmoc protected amino acid, 3 equivalents of DIPC and 0.5 equivalents of DMAP in DCM. The resin was agitated for 2 hours, rinsed with DCM and DMA. The resin was then treated with 10% acetic anhydride in DCM for 5 minutes. The resin was washed with DCM and MeOH and then dried *in vacuo*.

#### Method G35

The resin was washed with DCM and chloroform. A fresh 0.14M solution of tetrakis (triphenylphosphine) palladium(0) in 2.5% NMM, 5% HOAc in chloroform was added to the resin. After agitating for 1 hour, the resin was checked by the Kaiser ninhydrin test. If the Kaiser test was negative, a new solution of Pd(0) was made and the reaction done again until a positive Kaiser test results. The resin was rinsed with DCM, MeOH and DCM.

#### Method G36

The deprotected resin was treated for 1 hour with a solution of 10 equivalents of benzophenone imine and 1.3 equivalents of HOAc in DMA to form the glycine benzophenone imine. After rinsing with DMA the resin was treated with 3.5 equivalents of 2-*t*-butylimino-2-diethylamino-1, 3- dimethylperhydro- 1, 2, 3- diazaphosphorine for 1 hour. 3 equivalents of the

appropriate alkylating agent was added and the reaction agitated for 2 hours. The resin was drained and washed with NMP, 20% DIPEA in DCM, DCM, 10% HOAc in DCM and DCM. The benzophenone was removed with a solution of 10 equivalents of hydroxylamine•HCl in THF/H<sub>2</sub>O for 3 hours. The resin was then rinsed with H<sub>2</sub>O, THF 20% DIPEA in DCM and DCM.

5     **Method G37**

10         10 equivalents of 2-bromoterephthalic acid, 20 equivalents of HBTU, 20 equivalents of HOBt and 22 equivalents of DIPEA were dissolved in DMA and stirred for 15 minutes yielding the bisactivated 2-bromoterephthalic acid ester. To this solution was added 15 equivalents of 3-hydroxybenzylamine, Method G38, and 15 equivalents of DIPEA yielding the active ester of Compound E. The reaction was stirred for 30 minutes and then it was added to the resin which was then agitated over night.

**Method G38**

15         1 equivalent of 3-cyanophenol was placed in a Parr bottle with EtOH, 0.02 equivalents of HCl and 10% (w/w) of 10% Pd on carbon. The vessel was placed in the Parr shaker, charged with 50 psi H<sub>2</sub>, and shaken for 12 hours. The reaction filtered through a pad of celite and diluted 1:10 with Et<sub>2</sub>O. Upon standing over night, fine white needles form. The product was filtered, washed with Et<sub>2</sub>O and dried *in vacuo*. The resulting hydrochloride salt was then used without further purification.

**Method G39**

20         The resin was washed with DCM and chloroform. A fresh 0.14M solution of tetrakis(triphenylphosphine) palladium(0) in 2.5% NMM, 5% HOAc in chloroform was added to the resin. After agitating for 2 hours, the resin was drained and rinsed with DCM and DMA. The resin was then treated with 10% DIPEA in DMA for 10 minutes, followed by several DMA washes and then with a 5% solution of diethyldithiocarbamic acid in DMA for 15 minutes. The resin was then rinsed with DMA, DCM, MeOH and DCM.

25         **Method G40**

       Resin was suspended in ACN and cooled to 0°C. Once cool, 3 equivalents of Ph<sub>3</sub>P and 3 equivalents of NCS was added and the resin was agitated for 5 minutes. 6 equivalents of the appropriate aniline was added to the resin and the resin was agitated as it was warmed to room temperature. After an additional 10 minutes at room temperature, the reaction was quenched with 3 equivalents of HOAc and the resin washed with 10% HOAc in ACN, DCM and MeOH.

30         **Method G41**

       The resin was preactivated with 3 equivalents of HBTU, 3 equivalents of HOBt and 6 equivalents of DIPEA in DMA for 10 minutes. 2 equivalents of the appropriate amine was added, and the resin agitated for 30 minutes. The procedure was repeated again. The resin was rinsed with DMA and DCM.

**Method G42**

The resin was rinsed with DMA, DCM and dichloroethane. 1.1 equivalents of the appropriate sulfonyl chloride and 3 equivalents of DIPEA were added in dichloroethane and the resin was agitated for 12 hours. The reaction can be followed by the Kiaser ninhydrin test and the procedure repeated until a negative Kiaser test results. The resin was washed with dichloroethane, and DCM.

**Method G43**

The resin was rinsed with DMA, DCM and dichloroethane. 1.1 equivalents of the appropriate chloroformate and 3 equivalents of DIPEA were added in dichloroethane and the resin was agitated for 12 hours. The reaction can be followed by the Kiaser ninhydrin test and the procedure repeated until a negative Kiaser test results. The resin was washed with dichloroethane, and DCM.

**Method G44**

1 equivalent of the appropriate amine was dissolved in a 3:2 THF/H<sub>2</sub>O solution. 1.1 equivalents of solid NaHCO<sub>3</sub> and 1.1 equivalents of Boc<sub>2</sub>O were added and the solution was stirred overnight. The reaction was concentrated, and the residue was partitioned between H<sub>2</sub>O and Et<sub>2</sub>O. The aqueous layer was extracted with Et<sub>2</sub>O and the combined organic layers were dried over MgSO<sub>4</sub> and concentrated *in vacuo* to a solid. Recrystallization out of Et<sub>2</sub>O/hexane provided pure product.

**Method G45**

1 equivalent of the appropriate phenol was dissolved in DCM containing 2.6 equivalents of 2, 6-lutidine and the mixture was cooled to -78°C. After adding 1.25 equivalents of triflic anhydride the stirring reaction was allowed to warm to room temperature overnight. The reaction was then concentrated, and the residue was partitioned between Et<sub>2</sub>O and H<sub>2</sub>O. The aqueous layer was extracted with Et<sub>2</sub>O and the combined organic layers were dried over MgSO<sub>4</sub> and concentrated *in vacuo*. The residue was purified by silica gel flash chromatography (9:1 hexane/Et<sub>2</sub>O) to provide the pure triflate.

**Method G46**

To a stirring solution of 1 equivalent of the triflate in a 2/1 mixture of DMF/MeOH was added 0.15 equivalents of 1, 3-bis(diphenylphosphino)-propane and 2.5 equivalents of TEA. Carbon monoxide gas was bubbled through this solution for 15 minutes, then 0.15 equivalents of Pd(OAc)<sub>2</sub> was added and the reaction was stirred at 70°C for 5-7 hours under an atmosphere of CO (using a balloon filled with CO). The reaction was then concentrated *in vacuo*, and the residue was partitioned between Et<sub>2</sub>O and H<sub>2</sub>O. The aqueous layer was extracted twice with Et<sub>2</sub>O and the combined organic layers were dried over MgSO<sub>4</sub>, filtered through a plug of silica gel and concentrated *in vacuo*. The residue was purified by silica gel flash chromatography (9:1:0.02 hexane/DCM/Et<sub>2</sub>O) to provide the pure methyl ester

**Method G47**

1 equivalent of the appropriate Boc-aniline was dissolved in methanol and the solution saturated with HCl. The reaction was heated at 50°C for 3h, then concentrated *in vacuo*. The pale yellow solid was heated in 35% H<sub>2</sub>SO<sub>4</sub> until complete dissolution occurred. Upon cooling the mixture by the addition of ice H<sub>2</sub>O the amine bisulfate precipitated. The reaction flask was cooled in an ice bath and the mixture stirred vigorously while 1.1 equivalent of sodium nitrite in H<sub>2</sub>O was added drop wise. The reaction was stirred at 0°C for another 1.5 hours. After diluting the reaction with H<sub>2</sub>O, the reaction was heated at 80°C for 10 hours. The reaction was cooled to room temperature and extracted with EtOAc. The combined organic layers were dried over MgSO<sub>4</sub> and concentrated *in vacuo*. The residue was purified by silica gel flash chromatography (14:6:1 hexane/DCM/Et<sub>2</sub>O) to provide the pure phenol.

**Method G48**

1 equivalent of the appropriate methyl benzoate was dissolved in DCM and 1.5 equivalents of a 1.0M solution of BBr<sub>3</sub> was added. After stirring the reaction overnight, the reaction was quenched with ice and stirred for an additional 1.5 hours. The reaction was extracted three times with Et<sub>2</sub>O and the combined organic layers were dried over MgSO<sub>4</sub> and concentrated *in vacuo*. The residue was taken up in a minimal amount of saturated NaHCO<sub>3</sub>. The product was precipitated from this aqueous solution by the addition of concentrated HCl and then extracted into Et<sub>2</sub>O. The combined organic layers were dried over MgSO<sub>4</sub> and concentrated *in vacuo* to provide pure benzoic acid.

**Method G49**

1 equivalent of the appropriate carboxylic acid was dissolved in DMF. 1.1 equivalents of solid NaHCO<sub>3</sub> and 5 equivalents of allyl bromide were added and the resulting mixture was stirred at 45°C overnight. The reaction was then concentrated, and the residue was partitioned between Et<sub>2</sub>O and H<sub>2</sub>O. The aqueous layer was extracted three times with Et<sub>2</sub>O and the combined organic layers were dried over MgSO<sub>4</sub> and concentrated *in vacuo*. The residue was purified by silica gel flash chromatography (7:3 hexane/Et<sub>2</sub>O) to provide the pure allyl ester.

**Method G50**

To a solution of 1 equivalent of the appropriate allyl ester in THF was added 0.1 equivalents of tetrakis (triphenylphosphine) palladium(0) and 10 equivalents of morpholine. The reaction was stirred for 1.5 hours, then concentrated *in vacuo*. The residue was taken up in DCM, extracted three times with 1N HCl, dried over MgSO<sub>4</sub> and concentrated *in vacuo*. The residue was triturated with 1:1 hexane/Et<sub>2</sub>O, filtered through a plug of glass wool and concentrated *in vacuo* to provide the pure benzoic acid.

**Method G51**

1 equivalent of the phenol was dissolved in DMF and 2.05 equivalents of K<sub>2</sub>CO<sub>3</sub> and 4 equivalents of 1, 3-dibromopropane were added. The reaction was stirred overnight while heating the reaction flask in an oil bath maintained at 50°C. After concentrating the mixture *in vacuo*, the

residue was partitioned between Et<sub>2</sub>O and H<sub>2</sub>O. The aqueous layer was extracted three times with Et<sub>2</sub>O and the combined organic layers were dried over MgSO<sub>4</sub> and concentrated *in vacuo*. The residue was purified by silica gel flash chromatography (95:5 hexane/Et<sub>2</sub>O) to provide the pure bromide.

5   **Method G52**

1 equivalent of the appropriate hydroxy phenol and 1 equivalent of K<sub>2</sub>CO<sub>3</sub> were added to a solution of 0.5 equivalents of the bromide in DMF. After stirring overnight, the reaction was concentrated *in vacuo*. The residue was partitioned between Et<sub>2</sub>O and H<sub>2</sub>O. The aqueous layer was extracted three times with Et<sub>2</sub>O and the combined organic layers were dried over MgSO<sub>4</sub> and concentrated *in vacuo*. The residue was purified by silica gel flash chromatography (18:1 DCM/Et<sub>2</sub>O) to provide the pure phenol.

**Method G53**

To a nitrogen purged glass pressure tube was added 1 equivalent of the appropriate bromide, 5 equivalents of n-butyl vinyl ether, 15 equivalents of TEA, 0.1 equivalents of 1, 3-bis(diphenylphosphine)propane, 1 equivalent of thallium acetate, 0.09 equivalents of palladium acetate, and DMF. The tube was capped and heated to 100°C overnight. The reaction was cooled and the catalyst filtered off. The mixture was diluted with EtOAc and washed with H<sub>2</sub>O, and dried over MgSO<sub>4</sub>. The crude product was purified on silica (4/1 hexane/DCM). This was dissolved in THF and 4N HCl in dioxane and stirred overnight. The solvents were evaporated and the product purified on silica (4/1 hexane/EtOAc) to give pure product.

**Method G54**

1 equivalent of the appropriate Boc-aniline was dissolved in methanol and the solution saturated with HCl. The reaction was heated at 50°C for 3h, then concentrated *in vacuo*. The pale yellow solid was heated in 35% H<sub>2</sub>SO<sub>4</sub> until complete dissolution occurred. Upon cooling the mixture by the addition of ice H<sub>2</sub>O the amine bisulfate precipitated. The reaction flask was cooled in an ice bath and the mixture stirred vigorously while 1.1 equivalents of sodium nitrite in H<sub>2</sub>O was added drop wise. The reaction was stirred at 0°C for another 1.5 hours. An aqueous solution of 10 equivalents of KI was added, followed immediately with 17 equivalents CuI. The reaction was stirred at room temperature for 14 hours, then extracted 3 times with Et<sub>2</sub>O. The combined organic layers were washed with 1M NaHCO<sub>3</sub>, brine, and dried over MgSO<sub>4</sub>, then concentrated *in vacuo*. The residue was purified by silica gel flash chromatography (95:5 hexane/Et<sub>2</sub>O) to provide the pure iodide.

**Method G55**

2.3 equivalents of lithium iodide was added to 1 equivalent of methyl- 2, 6-dichloro- 4-iodobenzoate in pyridine, and the mixture heated at reflux for 8 hours. The reaction was concentrated *in vacuo* and the residue was partitioned between EtOAc and 1N HCl. The aqueous layer was extracted three times with EtOAc, and the combined organic layers were washed with 1M NaHCO<sub>3</sub>, dried over MgSO<sub>4</sub> and concentrated *in vacuo*. The residue was dissolved in NMM and the



solution concentrated *in vacuo*. The residue was taken up in DCM and then washed three times with 1N HCl. The organic layer was dried over  $\text{MgSO}_4$  and concentrated *in vacuo* to provide the benzoic acid in high enough purity to be used without further purification.

#### Method G56

5           1.3 equivalents of DIPEA was added to a heterogeneous mixture of 1 equivalent of 3-hydroxybenzoic acid, 1.3 equivalents of N, O-dimethylhydroxylamine hydrochloride, 1.3 equivalents of HOBt and 1.3 equivalents of EDC stirring in DMF. All solids eventually dissolved as the mixture was stirred at room temperature for 28 hours. After concentrating the mixture, the residue was partitioned between  $\text{Et}_2\text{O}$  and  $\text{H}_2\text{O}$ . The aqueous layer was extracted three times with  
10  $\text{Et}_2\text{O}$  and the combined organic layers were dried over  $\text{MgSO}_4$ , and concentrated *in vacuo*. The residue was purified by silica gel flash chromatography ( $\text{Et}_2\text{O}$ ) to provide the pure hydroxamate.

#### Method G57

To a stirred  $-78^\circ\text{C}$  solution of 1 equivalent of the appropriate protected hydroxamate in THF was added a solution of 1.2 equivalents of 1.5 M DIBAL in toluene drop wise. The reaction mixture  
15 was stirred for an additional 3 hours at  $-78^\circ\text{C}$  or until TLC showed clean formation of product, with only a trace of starting material. The reaction was quenched by adding to a separatory funnel containing  $\text{Et}_2\text{O}$  and 0.35M  $\text{NaHSO}_4$ . The layers were separated. The aqueous layer was extracted three times with ethyl ether. The combined organic layers were washed twice with 1N HCl, saturated aqueous  $\text{NaHCO}_3$ , and over  $\text{MgSO}_4$ , filtered through a plug of silica gel, and concentrated  
20 *in vacuo*. No further purification of the aldehyde was necessary.

#### Method G58

A solution of 1 equivalent of the appropriate aldehyde in THF was cooled to  $-78^\circ\text{C}$  and 1.1 equivalents of 0.5M ethynylmagnesium bromide/THF was added. After stirring the reaction at room temperature for 3 hours, it was diluted with  $\text{Et}_2\text{O}$  and washed twice with 10% citric acid. The  
25 combined aqueous layers were back-extracted once with  $\text{Et}_2\text{O}$ . The combined organic layers were washed twice with saturated aqueous  $\text{NaHCO}_3$ , dried over  $\text{MgSO}_4$  and concentrated *in vacuo*. The residue was purified by silica gel flash chromatography (4:1 to 3:2 hexane/ $\text{Et}_2\text{O}$ ) to provide the pure alkyne.

#### Method G59

30           1 equivalent of the aryl iodide was dissolved in EtOAc and the solution was degassed by passing  $\text{N}_2$  through a pipette and into the solution for 10 minutes. 1.25 equivalents of the alkyne was added, followed by 0.02 equivalents of dichlorobis(triphenylphosphine)palladium(II), 0.04 equivalents of CuI and 5 equivalents TEA. The reaction was stirred for 14 hours, diluted with EtOAc, washed twice with 5%  $\text{Na}_2\text{•EDTA}$ , brine and then dried over  $\text{MgSO}_4$  and concentrated *in*  
35 *vacuo*. The residue was purified by silica gel flash chromatography (gradient elution, using  $\text{Et}_2\text{O}$  to EtOAc) to provide the pure aryl alkyne.

**Method G60**

1 equivalent of the aryl alkyne was dissolved in MeOH and the solution was degassed by passing N<sub>2</sub> through a pipette and into the solution for 10 minutes. The 5% Rh/Al<sub>2</sub>O<sub>3</sub> was added, one balloon-full of hydrogen was passed through the solution, and the reaction was stirred under an atmosphere of H<sub>2</sub> (using a balloon) for 7 hours, after which the reaction was filtered through a pad of celite and concentrated *in vacuo*. The residue was purified by silica gel flash chromatography (gradient elution, using Et<sub>2</sub>O to EtOAc) to provide the pure product.

**Method G61**

2 equivalents of the appropriate protected amino acid and 2 equivalents of Ph<sub>3</sub>P was suspended in DCM. 2.2 equivalents of NCS was added and the mixture was stirred for 30 minutes. 1 equivalent of the aniline containing resin and 1.1 equivalents of NMM was suspended in DCM and the clear acid solution added. The resin was agitated for 2 hours, rinsed with DCM, DMA and DCM. The procedure was repeated again.

**Method G62**

The appropriate benzaldehyde was converted to its corresponding hydantoin by Method G63 and then hydrolyzed to the amino acid by Method G64. The pure racemic amino acid was then protected by Method G5.

**Method G63**

1 equivalent of the appropriate benzaldehyde, 2 equivalents of potassium cyanide and 4 equivalents of ammonium carbonate were refluxed in 50% EtOH for 2.5 hours. After cooling to 0°C, the solution was acidified to pH 2 with concentrated HCl. After standing in the refrigerator overnight, the crystals were filtered and washed with H<sub>2</sub>O and recrystallized from boiling H<sub>2</sub>O/EtOH.

**Method G64**

The pure hydantoin was refluxed in 10% NaOH overnight. After cooling, activated carbon was added and the solution filtered through celite. The solution was acidified to pH 7 with concentrated HCl and allowed to stand in the refrigerator overnight. The resulting crystals were filtered, washed with H<sub>2</sub>O and dried overnight *in vacuo* to give pure racemic amino acid.

**Method G65**

4-bromo-2-chlorobenzoic acid was converted to the *t*-butyl ester by Method G10. *t*-Butylvinyl ether was coupled to the bromide by Method G53 to give 4-acetyl-2-chlorobenzoic acid *t*-butyl ester. The ketone was reduced to the alcohol by Method G66 and the racemic mixture resolved by Method G67 to give pure *S* isomer. Phthalamide was coupled to the alcohol by Method G68 and the product hydrolyzed by Method G69 to give the amine.

**Method G66**

2 equivalents of the appropriate ketone was dissolved in MeOH and 1 equivalent of NaBH<sub>4</sub> was added. After stirring for 1 hour, the reaction was quenched with concentrated HCl and

concentrated *in vacuo*. The residue was partitioned between Et<sub>2</sub>O and H<sub>2</sub>O. The organics were dried over MgSO<sub>4</sub> and concentrated *in vacuo*. The alcohol can be used without further purification.

**Method G67**

1 equivalent of the alcohol mixture was dissolved in diisopropyl ether and 2 equivalents of vinylacetate and Amano lipase P (100mg) were added. The suspension was stirred overnight and then concentrated *in vacuo*. The residue was purified by silica gel flash chromatography (5/1 EtOAc/hexane) to give pure R and S isomers.

**Method G68**

A solution of 1 equivalent of the alcohol and 3 equivalents of Ph<sub>3</sub>P in THF was cooled to -10°C in an ice-EtOH bath. While stirring, a solution of 3 equivalents of the amine and 3 equivalents of DEAD in THF was added drop wise. The cold bath was removed and the reaction was stirred at room temperature overnight. The reaction was concentrated *in vacuo* and the resulting residue was taken up in a minimal amount of DCM and filtered through a plug of silica gel, using DCM as eluent. After concentrating this solution *in vacuo*, the residue was purified using silica gel flash chromatography (8/2/0.5 hexane/DCM/Et<sub>2</sub>O) to provide product.

**Method G69**

1 equivalent of the phthalamide was dissolved in EtOH and THF followed by addition of 8 equivalents of hydrazine hydrate. The reaction was stirred at room temperature for 1.5 hours, then at 50°C for 1 hour. The solution was cooled, filtered and the solids washed with EtOAc. The clear solution was concentrated *in vacuo* and the residue purified by silica gel flash chromatography (94/4 DCM/MeOH) to give pure amine.

**Method G70**

1 equivalent of the appropriate commercially available ketone, 5 equivalents of hydroxylamine hydrochloride and 10 equivalents of sodium acetate were combined in MeOH and stirred overnight. The reaction was concentrated *in vacuo* and the residue was partitioned between EtOAc and saturated NaHCO<sub>3</sub>. The organic layer was washed once with brine, dried over MgSO<sub>4</sub> and concentrated *in vacuo*. The product was purified by silica gel flash chromatography (Et<sub>2</sub>O) to give pure oxime.

**Method G71**

1 equivalent of the appropriate benzaldehyde was treated with 2.5 equivalents of the appropriate R'MgBr in THF at -20°C under an N<sub>2</sub> atmosphere. After warming to room temperature, the reaction was poured into a slurry of 0.1 N sulfuric acid and ice, and the product extracted with EtOAc. After partitioning and washing with brine, the organic phase was dried over MgSO<sub>4</sub> and concentrated *in vacuo* to give crude product. Oxidation to the ketone was carried out in dioxane with 1.1 equivalents of 2, 3-dichloro-5, 6-dicyano-1, 4-benzoquinone for 48 hours. Reaction contents were filtered, and the filtrate concentrated *in vacuo*. The residue was purified by silica gel flash chromatography (hexane/EtOAc 1:1) to yield the product as a yellow solid.

**Method G72**

The resin with the S-trityl or O-trityl protecting group was washed three times with DCM. It was then washed three times for 10 minutes with a solution consisting of 1% TFA 1% TES in DCM. It was then washed 3 times with DCM. The resin was then checked by placing a small amount of resin into a test tube and treating it with concentrated TFA. If no yellow color appears the removal was complete. If a yellow color appears, the above procedure was repeated until a clear test was achieved.

**Method G73**

The resin containing the appropriate free hydroxyl was washed three times with DCM. A solution of 10% DIPEA in DCM was added to the resin and a 0.3 M solution of phosgene in toluene was added to the resin. The reaction was allowed to proceed for 10 minutes at room temperature, after which it was drained and washed three times with DCM. A 0.3 M solution in DCM of the appropriate amine was added to the resin and it was allowed to react overnight. The resin was then drained and washed three times with DCM.

**Method G74**

The appropriate resin was washed three times with DCM and then treated with a 0.3 M solution of the appropriate chloroformate (R) in 0.33 M DIPEA in NMP overnight. The coupling was monitored by the Kaiser ninhydrin test. If the Kaiser test was positive, the appropriate chloroformate was coupled again in the same manner. The resin was then washed three times with NMP and then three times with DCM.

**Method G75**

The appropriate 2, 6- disubstituted phenol (2, 6- dichlorophenol for Compound F, 2, 6- dimethylphenol for Compound H and 2, 6- difluorophenol for Compound I) was alkylated by Method G76. The resulting phthalimide was hydrolyzed and protected by Method G77. The phenol was then converted to the triflate by Method G78 and carbonylated by Method G79 to give the desired double protected compound.

**Method G76**

A round bottom flask was equipped with an efficient overhead stirrer and charged with concentrated  $\text{H}_2\text{SO}_4$  (2.7 x volume of  $\text{H}_2\text{O}$ ) and  $\text{H}_2\text{O}$  and cooled to  $\sim -5^\circ\text{C}$  with an ethanol ice bath. Once cool, 1 equivalent of the appropriate disubstituted phenol and 1 equivalent of N-(hydroxymethyl)phthalimide were added with vigorous stirring. The reaction was kept cool for 4 hours and then allowed to warm to room temperature overnight with constant stirring. The reaction generally proceeds to a point where there was just a solid in the round bottom flask. At this point EtOAc and  $\text{H}_2\text{O}$  were added and stirred into the solid. Large chunks were broken up and then the precipitate was filtered and washed with more EtOAc and  $\text{H}_2\text{O}$ . The product was then used without further purification after drying overnight in a vacuum desiccator.

**Method G77**

1 equivalent of the product from Method G76 and (22.5ml x #g of starting material) of methanol was added to a round bottom flask equipped with a H<sub>2</sub>O condenser and stirring bar. 1.2 equivalents of hydrazine mono hydrate was added and the mixture was refluxed for 4 hours. After cooling to room temperature, (4.5ml x #g of starting material) of concentrated HCl was carefully added. Upon completion of the addition, the mixture was refluxed again overnight (> 8 hours). The reaction was cooled to 0°C and the precipitated by- product filtered off. The filtrate was then concentrated *in vacuo*. The residue was then Boc protected by Method G44 with the exception that the product was recrystallized from hot methanol and H<sub>2</sub>O.

**Method G78**

1 equivalent of the appropriate phenol and 1.5 equivalents of 2, 6- lutidine was dissolved, with mild heating if necessary, in DCM in a round bottom flask. Once the starting material has completely dissolved, the mixture was cooled to -78°C under N<sub>2</sub> with a dry ice ethanol bath. Once cool, 2.5 equivalents of triflic anhydride was added and the reaction was allowed to slowly come to room temperature with stirring. The reaction was monitored by TLC and was generally done in 4 hours. Upon completion, the reaction was concentrated *in vacuo* and the residue partitioned between EtOAc and H<sub>2</sub>O. The organic layer was washed twice with 0.1N H<sub>2</sub>SO<sub>4</sub>, twice with saturated NaHCO<sub>3</sub>, once with brine, dried over MgSO<sub>4</sub> and concentrated *in vacuo*. The residue was then purified on silica gel using DCM as eluent.

**Method G79**

1 equivalent of triflate was dissolved in DMF and MeOH in the glass insert of a high pressure Parr bomb. The starting material was then degassed while stirring with CO for 10 minutes. 0.15 equivalents palladium(II) acetate and 0.15 equivalents of 1, 3- bis(diphenylphosphino) propane were then added and the mixture was then degassed while stirring with CO for another 10 minutes. 2.5 equivalents of diisopropyl ethyl amine was added and the Parr bomb assembled. After properly assembling the bomb, it was charged with 300 psi CO gas and heated to 70°C with stirring overnight. The bomb was then cooled and vented. The mixture was transferred to a round bottom flask and concentrated *in vacuo*. The residue was then purified on silica gel using DCM with 1% acetone and 1% TEA as eluent.

**Method G81**

1 equivalent of the appropriate alkene and 1.5 equivalents of KOH were dissolved in H<sub>2</sub>O in an appropriately sized Parr shaker flask. A small amount (approximately 100mg per 50 mmol of alkene) of 5% Pd/C catalyst was added and the flask was charged with 50 psi H<sub>2</sub> and shaken overnight. The mixture was then filtered through Celite and concentrated *in vacuo*. The resulting product was used without further purification.

**Method G80**

1 equivalent of the appropriate ethyl ester and 1.5 equivalents of KOH was dissolved in H<sub>2</sub>O and refluxed for three hours. After completion, the reaction was concentrated *in vacuo* and the product used without further purification.

5 **Method G82**

1.2 equivalents of NaH (60% mineral oil dispersion) was suspended in benzene and cooled to 0°C with an ice H<sub>2</sub>O bath. 1.2 equivalents of triethyl phosphonoacetate was added slowly and the reaction was allowed to stir until the solution becomes clear. 1 equivalent of the appropriate ketone (R) was added slowly and the reaction was stirred for 4 hours. Upon completion, the reaction was partitioned with toluene and H<sub>2</sub>O. The aqueous layer was back extracted. The combined organic layers were dried over MgSO<sub>4</sub> and concentrated *in vacuo*. The residue was purified by silica gel flash chromatography (85:15 hexane/EtOAc).

**Method G83**

1.2 equivalents of NaH (60% mineral oil dispersion) was suspended in benzene and cooled to -10°C with a dry ice H<sub>2</sub>O bath. 1.2 equivalents of triethyl 2-phosphonopropionate was added slowly and the reaction was allowed to stir until the solution becomes clear. 1 equivalent of the appropriate aldehyde (R) was added slowly and the reaction was stirred for 4 hours. Upon completion, the reaction was partitioned with toluene and H<sub>2</sub>O. The aqueous layer was back extracted. The combined organic layers were dried over MgSO<sub>4</sub> and concentrated *in vacuo*. The residue was purified by silica gel flash chromatography (85:15 hexane/EtOAc).

**Method G84**

1 equivalent of the appropriately protected toluene was dissolved in acetic anhydride and HOAc, then cooled in an ice-salt bath (-5°C) before concentrated H<sub>2</sub>SO<sub>4</sub> was added. A solution of CrO<sub>3</sub> (2.6 equivalents) in acetic anhydride and HOAc was added drop wise and the reaction was stirred for 3.5 hours at -5°C. The reaction was poured into ice H<sub>2</sub>O and stirred for 30 min. The mixture was extracted three times with ethyl ether. The combined organic layers were washed with saturated NaHCO<sub>3</sub> and brine, then dried over MgSO<sub>4</sub> and concentrated *in vacuo* to an oil. Toluene was added to the oil and the solution concentrated *in vacuo* again. This was repeated to obtain a crystalline solid. The solid was dissolved in methanol and concentrated HCl and heated at reflux for 12 hours. The reaction was concentrated *in vacuo* and the residue was purified by silica gel flash chromatography (9:1 hexane/Et<sub>2</sub>O) to provide the pure aldehyde.

**Method G85**

1 equivalent of the appropriate alcohol was dissolved in DMF and cooled to -5°C in an ice-salt H<sub>2</sub>O bath. 1.4 equivalents lithium bis(trimethylsilyl)amide in THF was added drop wise. The reaction was stirred for 0.5 hour, then 1 equivalent of methyl iodide was added and the reaction was stirred overnight under an atmosphere of nitrogen. The reaction was partitioned between ethyl ether and 10% citric acid. The aqueous layer was extracted with ethyl ether, the combined organic layers were washed with saturated NaHCO<sub>3</sub> and brine, then dried over MgSO<sub>4</sub> and concentrated *in*

*vacuo* to an oil. The residue was purified by silica gel flash chromatography (9:1 hexane/Et<sub>2</sub>O) to provide the pure methyl ether.

#### Method G86

Commercially available nitroterephthalic acid was converted to its diethyl ester by Method G87. The nitro group was replaced by a benzyl mercaptan by Method G88 and deprotected by AlBr<sub>3</sub> using Method G89. The thiol was then alkylated with bromoacetaldehyde diethyl acetal by Method G90 and then dehydrated by Method G91. The diethyl ester was treated with LiOH, Method G4, and then coupled by Method G3 to 3-hydroxy benzyl amine, Method G38. The final ethyl ester was removed by Method G4.

#### 10 Method G87

1 equivalent of the appropriate commercially available carboxylic acid was dissolved in toluene with an excess of ethanol and 0.6 equivalents of H<sub>2</sub>SO<sub>4</sub> and the mixture refluxed for 4 days. Upon completion, the reaction was concentrated *in vacuo* and partitioned between EtOAc and H<sub>2</sub>O. The organic layer was washed with saturated NaHCO<sub>3</sub>, brine, dried over MgSO<sub>4</sub> and concentrated *in vacuo*. The product was used without further purification.

#### Method G88

1.25 equivalents of 95% NaH was suspended in DMF and cooled under N<sub>2</sub> to -5°C with an ice bath. 1.25 equivalents of benzyl mercaptan was added drop wise and the solution was allowed to stir for 40 minutes. 1 equivalent of the appropriate aryl nitro compound was added over 20 minutes and the mixture was stirred for an additional 30 minutes. After verifying that reaction was complete, the solution was poured onto ice and stirred until all the ice melts. The aqueous solution was partitioned three times with EtOAc and the combined organic layers were washed with brine, dried over MgSO<sub>4</sub> and concentrated *in vacuo*. The residue was purified by silica gel flash chromatography (1:4 hexane/EtOAc) to provide product.

#### 25 Method G89

1 equivalent of benzyl protected material and 2.2 equivalents of AlBr<sub>3</sub> were refluxed in toluene for 3 hours at which time H<sub>2</sub>O and enough EtOAc was added to partition the mixture. The organic layer was washed three times with H<sub>2</sub>O, brine, dried over MgSO<sub>4</sub> and concentrated *in vacuo*. The residue was purified by silica gel flash chromatography (4:1 hexane/EtOAc) to provide product.

#### 30 Method G90

1 equivalent of the thiol was dissolved in DMF and 2 equivalents of K<sub>2</sub>CO<sub>3</sub> was added. 1.1 equivalents of bromoacetaldehyde diethyl acetal was added slowly over 20 minutes and then 0.1 equivalent of NaI was added portion wise. The reaction was stirred for 2 hours and then partitioned between EtOAc and H<sub>2</sub>O. The organic layer was washed three times with H<sub>2</sub>O, brine, dried over MgSO<sub>4</sub> and concentrated *in vacuo*. The residue was purified by silica gel flash chromatography (9:1 hexane/EtOAc) to provide product.

**Method G91**

1 equivalent (by weight) of the appropriate diethyl acetal and 2 equivalents (by weight) of poly phosphoric acid were dissolved in chlorobenzene. The reaction was monitored by TLC. Upon completion of the reaction, the mixture was concentrated *in vacuo* and then partitioned between  
5 EtOAc and saturated NaHCO<sub>3</sub>. The organic layer was washed twice more with saturated NaHCO<sub>3</sub>, brine, dried over MgSO<sub>4</sub> and concentrated *in vacuo*. The residue was purified by silica gel flash chromatography (4:1 hexane/EtOAc) to provide product.

**Method G92**

1 equivalent of the appropriate carboxylic acid was dissolved in DCM and cooled to 0°C  
10 with an ice H<sub>2</sub>O bath. Once cool, 3 drops of DMF and 1.5 equivalents of oxalyl chloride were added. The reaction was stirred at 0°C for 1.5 hours and then for 0.5 hour at room temperature. At this time, the reaction was concentrated *in vacuo* and used immediately.

**Method G93**

1 equivalent of bis-N-carboxybenzoyl-cystine dibenzyl ester was dissolved in HOAc/H<sub>2</sub>O  
15 (9/1) and treated with chlorine gas for 10 minutes. The reaction was concentrated *in vacuo*, dissolved in toluene and concentrated *in vacuo* again to yield a white solid. This product was dissolved in DCM and 0.5 equivalents of the appropriate amine (R) was added. The reaction was stirred for 30 minutes and then diluted with EtOAc and partitioned with 0.1N H<sub>2</sub>SO<sub>4</sub> and then brine. The organic layer was dried over MgSO<sub>4</sub> and concentrated *in vacuo*. The residue was purified  
20 by silica gel flash chromatography (EtOAc/hexane 1:1) to yield pure product. The protecting groups were removed by Method G38 and the product used without further purification.

**Specific Example methods****Method S1**

Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L-  
25 diaminopropionic acid (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Dapa(alloc)- Wang resin). The resin was made by Method G34 using commercially available N-α-Fmoc-N-β-Alloc-L-diaminopropionic acid. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. The appropriate isocyanate (R) was coupled by Method G33. The completed molecule was worked up  
30 by Method G21.

**Method S2**

Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L-  
diaminobutyric acid (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Daba(alloc)- Wang  
resin). The resin was made by Method G34 using commercially available N-α-Fmoc-N-γ-Alloc-L-  
35 diaminobutyric acid. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. The appropriate isocyanate (R) was coupled by Method G33. The completed molecule was worked up by Method G21.



**Method S3**

Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L- Ornithine (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Orn(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\delta$ -Alloc-L- Ornithine. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. The appropriate isocyanate (R) was coupled by Method G33. The completed molecule was worked up by Method G21.

**Method S4**

Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L- Lysine (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Lys(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\epsilon$ -Alloc-L-lysine. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. The appropriate isocyanate (R) was coupled by Method G33. The completed molecule was worked up by Method G21.

**Method S5**

Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L- diaminopropionic acid (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Dapa(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\beta$ -Alloc-L-diaminopropionic acid. The Fmoc group was cleaved by Method G19. Compound C, Method G13 was coupled by Method G20. The Alloc group was removed by Method G35. The appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

**Method S6**

Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L- diaminobutyric acid (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Daba(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\gamma$ -Alloc-L-diaminobutyric acid. The Fmoc group was cleaved by Method G19. Compound C, Method G13 was coupled by Method G20. The Alloc group was removed by Method G35. The appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

**Method S7**

Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L- Ornithine (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Orn(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\delta$ -Alloc-L- Ornithine. The Fmoc group was cleaved by Method G19. Compound C, Method G13 was coupled by Method G20. The Alloc group was removed by Method G35. The appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

**Method S8**

Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L- Lysine (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Lys(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\epsilon$ -Alloc-L-lysine. The Fmoc group was cleaved by Method G19. Compound C, Method G13 was coupled by Method G20. The Alloc group was removed by Method G35. The appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

**Method S9**

Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L- diaminopropionic acid (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Dapa(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\beta$ -Alloc-L-diaminopropionic acid. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. Commercially available Fmoc- nipecotic acid was coupled by Method G20. The Fmoc group was removed by Method G19 and the appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

**Method S10**

Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L- diaminopropionic acid (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Dapa(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\beta$ -Alloc-L-diaminopropionic acid. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. Commercially available Fmoc- isonipecotic acid was coupled by Method G20. The Fmoc group was removed by Method G19 and the appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

**Method S11**

Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L- diaminopropionic acid (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Dapa(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\beta$ -Alloc-L-diaminopropionic acid. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. Commercially available Fmoc- 3-aminomethyl benzoic acid was coupled by Method G20. The Fmoc group was removed by Method G19 and the appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

**Method S12**

Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L- diaminopropionic acid (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Dapa(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\beta$ -

Alloc-L-diaminopropionic acid. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. Commercially available Fmoc- 4-aminomethyl benzoic acid was coupled by Method G20. The Fmoc group was removed by Method G19 and the appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

#### Method S13

Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L-diaminopropionic acid (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Dapa(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\beta$ -Alloc-L-diaminopropionic acid. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. Commercially available Fmoc-  $\beta$  alanine was coupled by Method G20. The Fmoc group was removed by Method G19 and the appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

#### Method S14

Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L-diaminopropionic acid (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Dapa(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\beta$ -Alloc-L-diaminopropionic acid. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. Commercially available Fmoc- glycine was coupled by Method G20. The Fmoc group was removed by Method G19 and the appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

#### Method S15

Compounds were synthesized using standard Fmoc solid phase methods on commercially available Fmoc- L- Ornithine (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Orn(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\delta$ -Alloc-L-Ornithine. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. Commercially available Fmoc- nipecotic acid was coupled by Method G20. The Fmoc group was removed by Method G19 and the appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

#### Method S16

Compounds were synthesized using standard Fmoc solid phase methods on commercially available Fmoc- L- Ornithine (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Orn(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\delta$ -Alloc-L-Ornithine. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. Commercially

available Fmoc- isonipecotic acid was coupled by Method G20. The Fmoc group was removed by Method G19 and the appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

#### Method S17

- 5       Compounds were synthesized using standard Fmoc solid phase methods on commercially available Fmoc- L- Ornithine (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Orn(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ - Fmoc-N- $\delta$ -Alloc-L-Ornithine. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. Commercially  
10       available Fmoc- pipecolic acid was coupled by Method G20. The Fmoc group was removed by Method G19 and the appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

#### Method S18

- 15       Compounds were synthesized using standard Fmoc solid phase methods on commercially available Fmoc- L- Ornithine (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Orn(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ - Fmoc-N- $\delta$ -Alloc-L-Ornithine. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. Commercially  
20       available Fmoc- 3-aminomethyl benzoic acid was coupled by Method G20. The Fmoc group was removed by Method G19 and the appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

#### Method S19

- 25       Compounds were synthesized using standard Fmoc solid phase methods on commercially available Fmoc- L- Ornithine (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Orn(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ - Fmoc-N- $\delta$ -Alloc-L-Ornithine. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. Commercially  
30       available Fmoc- 4-aminomethyl benzoic acid was coupled by Method G20. The Fmoc group was removed by Method G19 and the appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

#### Method S20

- 35       Compounds were synthesized using standard Fmoc solid phase methods on commercially available Fmoc- L- Ornithine (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Orn(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ - Fmoc-N- $\delta$ -Alloc-L-Ornithine. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. Commercially  
available Fmoc-  $\beta$  alanine was coupled by Method G20. The Fmoc group was removed by Method

G19 and the appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

#### Method S21

Compounds were synthesized using standard Fmoc solid phase methods on commercially available Fmoc- L- Ornithine (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Orn(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\delta$ -Alloc-L-Ornithine. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. Commercially available Fmoc- glycine was coupled by Method G20. The Fmoc group was removed by Method G19 and the appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

#### Method S22

Compounds were synthesized using standard Fmoc solid phase methods on N- $\alpha$ -Fmoc-N- $\gamma$ -Alloc-L-diaminobutyric acid- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Daba(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\gamma$ -Alloc-L-diaminobutyric acid. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. Commercially available Fmoc- nipecotic acid was coupled by Method G20. The Fmoc group was removed by Method G19 and the appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

#### Method S23

Compounds were synthesized using standard Fmoc solid phase methods on N- $\alpha$ -Fmoc-N- $\gamma$ -Alloc-L-diaminobutyric acid- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Daba(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\gamma$ -Alloc-L-diaminobutyric acid. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. Commercially available Fmoc- isonipecotic acid was coupled by Method G20. The Fmoc group was removed by Method G19 and the appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

#### Method S24

Compounds were synthesized using standard Fmoc solid phase methods on N- $\alpha$ -Fmoc-N- $\gamma$ -Alloc-L-diaminobutyric acid- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Daba(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\gamma$ -Alloc-L-diaminobutyric acid. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. Commercially available Fmoc- pipecolinic acid was coupled by Method G20. The Fmoc group was removed by Method G19 and the appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

**Method S25**

Compounds were synthesized using standard Fmoc solid phase methods on N- $\alpha$ -Fmoc-N- $\gamma$ -Alloc-L-diaminobutyric acid- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Daba(alloc)-Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\gamma$ -Alloc-L-diaminobutyric acid. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. Commercially available Fmoc- 3-aminomethyl benzoic acid was coupled by Method G20. The Fmoc group was removed by Method G19 and the appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

**Method S26**

Compounds were synthesized using standard Fmoc solid phase methods on N- $\alpha$ -Fmoc-N- $\gamma$ -Alloc-L-diaminobutyric acid- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Daba(alloc)-Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\gamma$ -Alloc-L-diaminobutyric acid. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. Commercially available Fmoc- 4-aminomethyl benzoic acid was coupled by Method G20. The Fmoc group was removed by Method G19 and the appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

**Method S27**

Compounds were synthesized using standard Fmoc solid phase methods on N- $\alpha$ -Fmoc-N- $\gamma$ -Alloc-L-diaminobutyric acid- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Daba(alloc)-Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\gamma$ -Alloc-L-diaminobutyric acid. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. Commercially available Fmoc-  $\beta$  alanine was coupled by Method G20. The Fmoc group was removed by Method G19 and the appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

**Method S28**

Compounds were synthesized using standard Fmoc solid phase methods on N- $\alpha$ -Fmoc-N- $\gamma$ -Alloc-L-diaminobutyric acid- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Daba(alloc)-Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\gamma$ -Alloc-L-diaminobutyric acid. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. Commercially available Fmoc- glycine was coupled by Method G20. The Fmoc group was removed by Method G19 and the appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

**Method S29**

Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L- Lysine (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Lys(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\epsilon$ -Alloc-L-lysine. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. Commercially available Fmoc- nipecotic acid was coupled by Method G20. The Fmoc group was removed by Method G19 and the appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

**Method S30**

Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L- Lysine (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Lys(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\epsilon$ -Alloc-L-lysine. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. Commercially available Fmoc- isonipecotic acid was coupled by Method G20. The Fmoc group was removed by Method G19 and the appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

**Method S31**

Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L- Lysine (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Lys(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\epsilon$ -Alloc-L-lysine. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. Commercially available Fmoc- pipecolinic acid was coupled by Method G20. The Fmoc group was removed by Method G19 and the appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

**Method S32**

Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L- Lysine (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Lys(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\epsilon$ -Alloc-L-lysine. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. Commercially available Fmoc- 3-aminomethyl benzoic acid was coupled by Method G20. The Fmoc group was removed by Method G19 and the appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

**Method S33**

Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L- Lysine (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Lys(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\epsilon$ -Alloc-L-lysine. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. Commercially available Fmoc- 4-aminomethyl benzoic acid was coupled by Method G20. The Fmoc group was removed by Method G19 and the appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

**Method S34**

Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L- Lysine (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Lys(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\epsilon$ -Alloc-L-lysine. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. Commercially available Fmoc-  $\beta$  alanine was coupled by Method G20. The Fmoc group was removed by Method G19 and the appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

**Method S35**

Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L- Lysine (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Lys(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\epsilon$ -Alloc-L-lysine. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. Commercially available Fmoc- glycine was coupled by Method G20. The Fmoc group was removed by Method G19 and the appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

**Method S36**

Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L- diaminopropionic acid (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Dapa(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\beta$ -Alloc-L-diaminopropionic acid. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. The appropriate chloroformate (R) was coupled by Method G74. The completed molecule was worked up by Method G21.

**Method S37**

Compounds were synthesized using standard Fmoc solid phase methods on commercially available Fmoc- L- tryptophan(Boc)- Wang resin (0.5 mmol/g). The Fmoc group was cleaved by Method G19. Compound D, Method G14, was coupled by Method G20. The Fmoc group was



cleaved by Method G19. The appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

#### Method S38

Compounds were synthesized using standard Fmoc solid phase methods on commercially available Fmoc- L- alanine- Wang resin (0.5 mmol/g). The Fmoc group was cleaved by Method G19. Compound D, Method G14, was coupled by Method G20. The Fmoc group was cleaved by Method G19. The appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

#### Method S39

Compounds were synthesized using standard Fmoc solid phase methods on commercially available Fmoc- L- asparagine(Trt)- Wang resin (0.5 mmol/g). The Fmoc group was cleaved by Method G19. Compound D, Method G14, was coupled by Method G20. The Fmoc group was cleaved by Method G19. The appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

#### Method S40

Compounds were synthesized using standard Fmoc solid phase methods on commercially available Fmoc- L- tryptophan(Boc)- Wang resin (0.5 mmol/g). The Fmoc group was cleaved by Method G19. 4- amino 2- methylbenzoic acid was coupled by Method G20. The appropriate carboxylic acid (R) was silyl protected, Method G18, and the acid chloride generated by Method G92 and coupled in DCM over night to the amine. After washing the resin with DCM and THF, 3 equivalents of tetrabutylammonium fluoride in THF was added. After 20 minutes, the resin was washed with THF, H<sub>2</sub>O and dilute HOAc. The completed molecule was worked up by Method G21.

#### Method S41

Compounds were synthesized using standard Fmoc solid phase methods on commercially available Fmoc- L- amino acid- Wang resins (0.5 mmol/g) (R). The Fmoc group was cleaved by Method G19. 4- amino 2- methylbenzoic acid was coupled by Method G20. The 3- hydroxy phenylacetic acid was silyl protected, Method G18, and the acid chloride generated by Method G92 and coupled in DCM over night to the amine. After washing the resin with DCM and THF, 3 equivalents of TBAF in THF was added. After 20 minutes, the resin was washed with THF, H<sub>2</sub>O and dilute HOAc. The completed molecule was worked up by Method G21.

#### Method S42

Compounds were synthesized using standard Fmoc solid phase methods on commercially available Fmoc- L- alanine- Wang resin (0.5 mmol/g). The Fmoc group was cleaved by Method G19. Commercially available 4- amino 2-chloro benzoic acid was coupled by Method G20. Fmoc- glycine was coupled to the aniline by Method G61. The Fmoc group was cleaved by Method G19. The appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

**Method S43**

Compounds were synthesized using standard Fmoc solid phase methods on commercially available Fmoc- L- alanine- Wang resin (0.5 mmol/g). The Fmoc group was cleaved by Method G19. Commercially available 4- amino 2-chloro benzoic acid was coupled by Method G20. Fmoc- L- alanine was coupled to the aniline by Method G61. The Fmoc group was cleaved by Method G19. The appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

**Method S44**

Compounds were synthesized using standard Fmoc solid phase methods on commercially available Fmoc- L- alanine- Wang resin (0.5 mmol/g). The Fmoc group was cleaved by Method G19. Commercially available 4- amino 2-chloro benzoic acid was coupled by Method G20. Fmoc- L- phenylglycine was coupled to the aniline by Method G61. The Fmoc group was cleaved by Method G19. The appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

**Method S45**

Compounds were synthesized using standard Fmoc solid phase methods on commercially available Fmoc- L- alanine- Wang resin (0.5 mmol/g). The Fmoc group was cleaved by Method G19. Commercially available 4- amino 2-chloro benzoic acid was coupled by Method G20. Fmoc- L- glutamine was coupled to the aniline by Method G61. The Fmoc group was cleaved by Method G19. The appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

**Method S46**

Compounds were synthesized using standard Fmoc solid phase methods on commercially available Fmoc- L- alanine- Wang resin (0.5 mmol/g). The Fmoc group was cleaved by Method G19. Commercially available 4- amino 2-chloro benzoic acid was coupled by Method G20. 3- chloro benzaldehyde was converted to Fmoc- 3- chloro- phenylglycine by Method G62, and coupled to the aniline by Method G61. The Fmoc group was cleaved by Method G19. The appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

**Method S47**

Compounds were synthesized using standard Fmoc solid phase methods on commercially available Fmoc- L- diaminopropionic acid(alloc)- Wang resin (0.5 mmol/g). The Fmoc group was cleaved by Method G19. Compound D, Method G14, was coupled by Method G20. The Fmoc group was cleaved by Method G19. The appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

**Method S48**

Compounds were synthesized using standard Fmoc solid phase methods on commercially available Fmoc- L- Lysine(Boc)- Wang resin (0.5 mmol/g). The Fmoc group was cleaved by Method G19. Compound D, Method G14, was coupled by Method G20. The Fmoc group was cleaved by

Method G19. The appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

#### Method S49

Compounds were synthesized using standard Fmoc solid phase methods on commercially available Fmoc- L- alanine- Wang resin (0.5 mmol/g). The Fmoc group was cleaved by Method G19. Commercially available 4- amino 2-chloro benzoic acid was coupled by Method G20. 3- methoxy benzaldehyde was converted to Fmoc- 3- chloro- phenylglycine by Method G62, and coupled to the aniline by Method G61. The Fmoc group was cleaved by Method G19. The appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

#### 10 Method S50

Compounds were synthesized using standard Fmoc solid phase methods on commercially available Fmoc- L- alanine- Wang resin (0.5 mmol/g). The Fmoc group was cleaved by Method G19. Commercially available 4- amino 2-chloro benzoic acid was coupled by Method G20. Fmoc- meta tyrosine was coupled to the aniline by Method G61. The Fmoc group was cleaved by Method G19. The appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

#### Method S51

3-hydroxy aniline was coupled to commercially available Boc- d- serine by Method G3. The Boc group was removed by Method G1 and this amine was coupled to Compound A, Method G8. The *t*-butyl ester was removed by Method G11 and the acid coupled to the appropriate amino acid O-*t*-butyl ester (R) by Method G3. The final *t*-butyl ester was removed by Method G11, and the completed molecule was purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

#### Method S52

The Boc group on Compound F, Method G75, was removed by Method G2 and furylacrylic acid was coupled to the amine after free basing, Method G2, by Method G3. The methyl ester was removed by Method G55 and the resulting acid coupled by Method G20 to the appropriate deprotected commercially available Fmoc protected amino acid Wang resin (0.5 mmol/g) (R). The completed molecule was worked up by Method G21.

#### 30 Method S53

The methyl ester of Compound F, Method G75, was removed by Method G55 and the resulting acid coupled by Method G20 to commercially available L- asparagine *t*-butyl ester. The Boc group was removed by Method G1 and the appropriate carboxylic acid (R) was coupled by Method G3. After removing the final *t*-butyl ester by Method G11, the molecule was purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

#### Method S54

The Boc group on Compound F, Method G75, was removed by Method G2 and furylacrylic acid was coupled to the amine after free basing, Method G2, by Method G3. The methyl

ester was removed by Method G55 and the resulting acid coupled by Method G20 to commercially available  $\beta$ -Boc-diaminopropionic acid methyl ester. The Boc group was removed by Method G1 and the appropriate carboxylic acid (R) was coupled by Method G3. After saponification, Method G4, the molecule was purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

#### Method S55

The Boc group on Compound I, Method G75, was removed by Method G1 and 3-hydroxybenzoic acid was coupled to the amine after free basing, Method G2, by Method G3. The methyl ester was removed by Method G55 and the resulting acid coupled by Method G20 to commercially available L-tryptophan methyl ester. After saponification, Method G4, the molecule was purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

#### Method S56

The Boc group on Compound H, Method G75, was removed by Method G1 and 3-hydroxybenzoic acid was coupled to the amine after free basing, Method G2, by Method G3. The methyl ester was removed by Method G55 and the resulting acid coupled by Method G20 to commercially available amino acid methyl ester (R). After saponification, Method G4, the molecule was purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

#### Method S57

The Boc group on Compound H, Method G75, was removed by Method G1 and furylacrylic acid was coupled to the amine after free basing, Method G2, by Method G3. The methyl ester was removed by Method G55 and the resulting acid coupled by Method G20 to the appropriate commercially available amino acid methyl ester (R). The Boc group was removed by Method G1 if needed and after saponification, Method G4, the molecule was purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

#### Method S58

The Boc group on Compound H, Method G75, was removed by Method G1 and 3-(2-thienyl)acrylic acid was coupled to the amine after free basing, Method G2, by Method G3. The methyl ester was removed by Method G55 and the resulting acid coupled by Method G20 to the appropriate commercially available amino acid methyl ester (R). The Boc group was removed by Method G1 if needed and after saponification, Method G4, the molecule was purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

#### Method S59

The Boc group on Compound H, Method G75, was removed by Method G1 and furylacrylic acid was coupled to the amine after free basing, Method G2, by Method G3. The methyl ester was removed by Method G55 and the resulting acid coupled by Method G20 to commercially available  $\beta$ -Boc-diaminopropionic acid methyl ester. The Boc group was removed by Method G1

and the appropriate carboxylic acid (R) was coupled by Method G3. After saponification, Method G4, the molecule was purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

**Method S60**

- 5           Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L- Lysine (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Lys(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\epsilon$ -Alloc-L-lysine. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. The appropriate aldehyde (R) was coupled by  
10   Method G23. The completed molecule was worked up by Method G21.

**Method S61**

- Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L- diaminopropionic acid (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Dapa(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\beta$ -  
15   Alloc-L-diaminopropionic acid. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. The appropriate aldehyde (R) was coupled by Method G23. The completed molecule was worked up by Method G21.

**Method S62**

- 20           The appropriate amine (R) was coupled to Compound A, Method G8, by Method G3. The *t*-butyl ester was removed by Method G11. The resulting acid was coupled by Method G3 to resin made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\beta$ -Alloc-L-diaminopropionic acid where the Fmoc group had been removed by Method G19. The completed molecule was worked up by Method G21.

25   **Method S63**

          The appropriate amine (R) was coupled to Compound A, Method G8, by Method G3. The *t*-butyl ester was removed by Method G11. The resulting acid was coupled by Method G3 to commercially available Fmoc- L- asparagine(Trt)- Wang resin (0.5 mmol/g) where the Fmoc group had been removed by Method G19. The completed molecule was worked up by Method G21.

30   **Method S64**

- The Boc group on Compound F, Method G75, was removed by Method G1 and reduced furylacrylic acid, Method G81, was coupled to the amine after free basing, Method G2, by Method G3. The methyl ester was removed by Method G55 and the resulting acid coupled by Method G20 to commercially available  $\beta$ - Boc- diaminopropionic acid methyl ester. The Boc group was removed  
35   by Method G1 and thiophene 2- carboxylic acid was coupled by Method G3. After saponification, Method G4, the molecule was purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

**Method S65**

The Boc group on Compound F, Method G75, was removed by Method G1. 2- acetylfuran was converted to the methyl acrylic acid ethyl ester by Method G82 and after saponification by Method G80 was coupled to the amine after free basing, Method G2, by Method G3. The methyl ester was removed by Method G55 and the resulting acid coupled by Method G20 to commercially available  $\beta$ - Boc- diaminopropionic acid methyl ester. The Boc group was removed by Method G1 and thiophene 2- carboxylic acid was coupled by Method G3. After saponification, Method G4, the molecule was purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

**Method S66**

The Boc group on Compound F, Method G75, was removed by Method G1. After 2- acetylfuran was converted to the methyl acrylic acid ethyl ester by Method G82, saponified by Method G80 and reduced by Method G81, it was coupled to the amine after free basing, Method G2, by Method G3. The methyl ester was removed by Method G55 and the resulting acid coupled by Method G20 to commercially available  $\beta$ - Boc- diaminopropionic acid methyl ester. The Boc group was removed by Method G1 and thiophene 2- carboxylic acid was coupled by Method G3. After saponification, Method G4, the molecule was purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

**Method S67**

The Boc group on Compound F, Method G75, was removed by Method G1. Furfuraldehyde was converted to the methyl acrylic acid ethyl ester by Method G83 and after saponification by Method G80 was coupled to the amine after free basing, Method G2, by Method G3. The methyl ester was removed by Method G55 and the resulting acid coupled by Method G20 to commercially available  $\beta$ - Boc- diaminopropionic acid methyl ester. The Boc group was removed by Method G1 and thiophene 2- carboxylic acid was coupled by Method G3. After saponification, Method G4 the molecule was purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

**Method S68**

The Boc group on Compound F, Method G75, was removed by Method G1. After furfuraldehyde was converted to the methyl acrylic acid ethyl ester by Method G83, saponified by Method G80 and reduced by Method G81, it was coupled to the amine after free basing, Method G2, by Method G3. The methyl ester was removed by Method G55 and the resulting acid coupled by Method G20 to commercially available  $\beta$ - Boc- diaminopropionic acid methyl ester. The Boc group was removed by Method G1 and thiophene 2- carboxylic acid was coupled by Method G3. After saponification, Method G4, the molecule was purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

**Method S69**

Compounds were synthesized using standard Fmoc solid phase methods on the appropriate commercially available Fmoc- L- amino acid- Wang resin (0.5 mmol/g) (R). The Fmoc group was cleaved by Method G19. The commercially available 2, 6 dimethyl terephthalic acid was coupled by Method G20. 3- hydroxy benzylamine, Method G38, was coupled by Method G20. The completed molecule was worked up by Method G21 and correct stereochemistry was assigned by activity.

**Method S70**

Compounds were synthesized on resin made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\beta$ -Alloc-L-diaminopropionic acid. The Fmoc group was cleaved by Method G19. The commercially available 2, 6 dimethyl terephthalic acid was coupled by Method G20. 3- hydroxy benzylamine, Method G38, was coupled by Method G20. The Alloc group was removed by Method G35 and the appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21 and correct stereochemistry was assigned by activity.

**Method S71**

The Boc group on Compound F, Method G75, was removed by Method G1 and the appropriate carboxylic acid (R) was coupled to the amine after free basing, Method G2, by Method G3. The methyl ester was removed by Method G55 and the resulting acid coupled by Method G20 to commercially available  $\beta$ - Boc- diaminopropionic acid methyl ester. The Boc group was removed by Method G1 and thiophene 2- carboxylic acid was coupled by Method G3. After saponification, Method G4, the molecule was purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

**Method S72**

Compounds were synthesized using standard Fmoc solid phase methods on commercially available Fmoc- L- tryptophan(Boc)- Wang resin (0.5 mmol/g). The Fmoc group was cleaved by Method G19. Commercially available 2- bromo terephthalic acid was protected with an Fmoc group by Method G6 and the resulting product was coupled by Method G20. The appropriate amine (R) was coupled by Method G22. The completed molecule was worked up by Method G21.

**Method S73**

Compounds were synthesized using standard Fmoc solid phase methods on commercially available Fmoc- L- alanine- Wang resin (0.5 mmol/g). The Fmoc group was cleaved by Method G19. Commercially available 2- bromo terephthalic acid was protected with an Fmoc group by Method G6 and the resulting product was coupled by Method G20. The appropriate amine (R) was coupled by Method G22. The completed molecule was worked up by Method G21.

**Method S74**

Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L- diamiobutyric acid (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Daba(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\gamma$ -Alloc-L-

diaminobutyric acid. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. The appropriate commercially available sulfonyl chloride (R) was coupled by Method G42. The completed molecule was worked up by Method G21.

5   **Method S75**

Compounds were synthesized using standard Fmoc solid phase methods on N- $\alpha$ -Fmoc-N- $\delta$ -Alloc-L-Ornithine- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Orn(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\delta$ -Alloc-L-Ornithine. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. The appropriate commercially available sulfonyl chloride (R) was coupled by Method G42. The completed molecule was worked up by Method G21.

**Method S76**

Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L- Lysine (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Lys(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\epsilon$ -Alloc-L-lysine. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. The appropriate commercially available sulfonyl chloride (R) was coupled by Method G42. The completed molecule was worked up by Method G21.

20   **Method S77**

Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L- diaminobutyric acid (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Daba(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\gamma$ -Alloc-L-diaminobutyric acid. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. The appropriate commercially available chloroformate (R) was coupled by Method G43. The completed molecule was worked up by Method G21.

**Method S78**

Compounds were synthesized using standard Fmoc solid phase methods on N- $\alpha$ -Fmoc-N- $\delta$ -Alloc-L-Ornithine- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Orn(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\delta$ -Alloc-L-Ornithine. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. The appropriate commercially available chloroformate (R) was coupled by Method G43. The completed molecule was worked up by Method G21.

35   **Method S79**

Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L- Lysine (alloc)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- Lys(alloc)- Wang resin). The



resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\epsilon$ -Alloc-L-lysine. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The Alloc group was removed by Method G35. The appropriate commercially available chloroformate (R) was coupled by Method G43. The completed molecule was worked up by Method G21.

#### Method S80

Compounds were synthesized using standard Fmoc solid phase methods on commercially available Fmoc- L- asparagine(Trt)- Wang resin (0.5 mmol/g). The Fmoc group was cleaved by Method G19. Commercially available 2- bromo terephthalic acid was protected with an Fmoc group by Method G6 and the resulting product was coupled by Method G20. The appropriate amine (R) was coupled by Method G22. The completed molecule was worked up by Method G21.

#### Method S81

Compounds were synthesized on resin made by Method G34 using commercially available N- $\alpha$ -Fmoc-N- $\beta$ -Alloc-L-diaminopropionic acid. The Fmoc group was cleaved by Method G19. Commercially available 2- bromo terephthalic acid was protected with an Fmoc group by Method G6 and the resulting product was coupled by Method G20. The appropriate amine (R) was coupled by Method G22. The completed molecule was worked up by Method G21.

#### Method S82

Compounds were synthesized using standard Fmoc solid phase methods on the appropriate commercially available Fmoc- amino acid p- alkoxybenzyl alcohol resin (R) (Wang resin) (0.5 mmol/g). The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The completed molecule was worked up by Method G21.

#### Method S83

Compounds were synthesized using standard Fmoc solid phase methods on the appropriate commercially available Fmoc- amino acid p- alkoxybenzyl alcohol resin (R) (Wang resin) (0.5 mmol/g). The Fmoc group was cleaved by Method G19. Compound B, Method G12, was coupled by Method G20. The completed molecule was worked up by Method G21.

#### Method S84

Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L- tryptophan(Boc)- Wang resin (0.5 mmol/g). The Fmoc group was cleaved by Method G19. Commercially available 4-amino 2-chlorobenzoic acid was coupled by Method G20. The resin was treated with an excess of 0.5M 4- nitrophenyl chloroformate and 0.5M DIPEA for 45 minutes. After twice washing the resin with THF/DCM, an excess of the appropriate amine (R) in 0.5M DIPEA/DMF was added and the resin bubbled for 20 minutes. The completed molecule was worked up by Method G21.

#### Method S85

The appropriate amino acid (R) was converted to its methyl ester by Method G15. After free basing the amine by Method G2, Compound C, Method G13, was coupled to the amino acid methyl

ester by Method G3. After saponification, Method G4, the molecule was purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

**Method S86**

3-hydroxyacetophenone was converted to the oxime by Method G70 and then hydrogenated by Method G38 to give the amine. This amine was then coupled to Compound A, Method G8, by Method G24. After removal of the *t*-butyl ester by Method G11, the acid was coupled to commercially available L-asparagine *t*-butyl ester by Method G24. The final *t*-butyl ester was removed by Method G11 and the completed molecule was purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

**Method S87**

3-hydroxyacetophenone was converted to the oxime by Method G70 and then hydrogenated by Method G38 to give the amine. This amine was then coupled to Compound A, Method G8, by Method G24. After removal of the *t*-butyl ester by Method G11, the acid was coupled to commercially available L-tryptophan methyl ester by Method G24. The final methyl ester was removed by Method G4 and the completed molecule was purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

**Method S88**

3-hydroxybenzaldehyde and ethyl magnesium bromide were converted to the ketone by Method G71. The ketone was then converted to the oxime by Method G70 and then hydrogenated by Method G38 to give the amine. This amine was then coupled to Compound A, Method G8, by Method G24. After removal of the *t*-butyl ester by Method G11, the acid was coupled to commercially available L-asparagine *t*-butyl ester by Method G24. The final *t*-butyl ester was removed by Method G11 and the completed molecule was purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

**Method S89**

3-hydroxybenzaldehyde and ethyl magnesium bromide were converted to the ketone by Method G71. The ketone was then converted to the oxime by Method G70 and then hydrogenated by Method G38 to give the amine. This amine was then coupled to Compound A, Method G8, by Method G24. After removal of the *t*-butyl ester by Method G11, the acid was coupled to commercially available L-tryptophan methyl ester by Method G24. The final methyl ester was removed by Method G4 and the completed molecule was purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

**Method S90**

3-hydroxybenzaldehyde and N-propyl magnesium bromide were converted to the ketone by Method G71. The ketone was then converted to the oxime by Method G70 and then hydrogenated by Method G38 to give the amine. This amine was then coupled to Compound A, Method G8, by Method G24. After removal of the *t*-butyl ester by Method G11, the acid was coupled to commercially available L-asparagine *t*-butyl ester by Method G24. The final *t*-butyl ester

was removed by Method G11 and the completed molecule was purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

#### Method S91

3-hydroxybenzaldehyde and N-propyl magnesium bromide were converted to the ketone by Method G71. The ketone was then converted to the oxime by Method G70 and then hydrogenated by Method G38 to give the amine. This amine was then coupled to Compound A, Method G8, by Method G24. After removal of the *t*-butyl ester by Method G11, the acid was coupled to commercially available L-tryptophan methyl ester by Method G24. The final methyl ester was removed by Method G4 and the completed molecule was purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

#### Method S92

The appropriate sulfonamide was synthesized by Method G93 using ammonia as the amine (R) and this product converted to the methyl ester by Method G15. Compound C, Method G13, was coupled to the sulfonamide methyl ester by Method G3. The finale methyl ester was removed by Method G4. The completed molecule was purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

#### Method S93

Compounds were synthesized on commercially available Fmoc- L- asparagine(Trt)- Wang resin (0.5 mmol/g). The Fmoc group was removed by Method G19. The product of Method G65, with the exception that it was not resolved by Method G67, was Fmoc protected by Method G5 and the *t*-butyl ester removed by Method G11. This product was coupled to the resin by Method G20. The Fmoc group was removed by Method G19 and the appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

#### Method S94

Compounds were synthesized on commercially available Fmoc- L- asparagine(Trt)- Wang resin (0.5 mmol/g). The Fmoc group was removed by Method G19. The Method S isomer of Method G65 was Fmoc protected by Method G5 and the *t*-butyl ester removed by Method G11. This product was coupled to the resin by Method G20. The Fmoc group was removed by Method G19 and the appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

#### Method S95

Compounds were synthesized on commercially available Fmoc- L- alanine- Wang resin (0.5 mmol/g). The Fmoc group was removed by Method G19. The S isomer of Method G65 was Fmoc protected by Method G5 and the *t*-butyl ester removed by Method G11. This product was coupled to the resin by Method G20. The Fmoc group was removed by Method G19 and the appropriate carboxylic acid (R) was coupled by Method G20. The completed molecule was worked up by Method G21.

**Method S96**

Compounds were synthesized using standard Fmoc solid phase methods on commercially available Fmoc- L- tryptophan(Boc)- Wang resin (0.5 mmol/g). The Fmoc group was cleaved by Method G19. The appropriate commercially available di- acid (R) coupled by Method G20. 3-  
5 hydroxy benzylamine, Method G38, was coupled by Method G20. The completed molecule was worked up by Method G21 and correct stereochemistry was assigned by activity.

**Method S97**

Compounds were synthesized using standard Fmoc solid phase methods on commercially available Fmoc- L- asparagine(Trt)- Wang resin (0.5 mmol/g). The Fmoc group was cleaved by  
10 Method G19. The appropriate commercially available di- acid (R) coupled by Method G20. 3- hydroxy benzylamine, Method G38, was coupled by Method G20. The completed molecule was worked up by Method G21 and correct stereochemistry was assigned by activity.

**Method S98**

The product of Method G86 was coupled by Method G20 to the appropriate commercially  
15 available Fmoc- amino acid Wang resin (R) after removing the Fmoc group by Method G19. The completed molecule was worked up by Method G21 and correct stereochemistry was assigned by activity.

**Method S99**

3- hydroxymandelic acid was converted to its corresponding alcohol by Method G25 and  
20 coupled to the methyl ester of 4- hydroxy 2- chlorobenzoic acid, Method G15, by Method G26. The methyl ester removed by Method G4 and the carboxylic acid was coupled to L- asparagine *t*- butyl ester by Method G3. The final *t*- butyl ester was removed by Method G11 and the molecule was purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

**Method S100**

3- hydroxymandelic acid was converted to its corresponding alcohol by Method G25 and  
coupled to the methyl ester of 4- hydroxy 2- chlorobenzoic acid, Method G15, by Method G26. The methyl ester removed by Method G4 and the carboxylic acid was coupled to L- alanine *t*- butyl ester by Method G3. The final *t*- butyl ester was removed by Method G11 and the molecule was purified  
30 by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

**Method S101**

The methyl ester of 3-(3-hydroxyphenyl) propionic acid was made by Method G15 and converted to the aldehyde by Method G29. The oxazoline of 4- bromo 2-chloro benzoic acid was made by Method G30. The aldehyde was coupled to the bromide by Method G31 and the oxazoline  
35 converted to the ethyl ester by Method G32. After saponification by Method G4, the carboxylic acid was coupled to L- alanine methyl ester by Method G3. After saponification by Method G4, the molecule was purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

**Method S102**

The methyl ester of 3-(3-hydroxyphenyl) propionic acid was made by Method G15 and converted to the aldehyde by Method G29. The oxazoline of 4-bromo-2-chlorobenzoic acid was made by Method G30. The aldehyde was coupled to the bromide by Method G31 and the oxazoline converted to the ethyl ester by Method G32. The allylic alcohol was oxidized to the ketone by Method G27 and the ethyl ester was saponified by Method G4. The carboxylic acid was coupled to L-alanine methyl ester by Method G3; and after saponification by Method G4, the molecule was purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

**Method S103**

The methyl ester of 4-hydroxy-2-chlorobenzoic acid was formed by Method G15. 1,2-dibromoethane was coupled to the phenol by Method G51. The appropriate hydroxy phenol (R) was coupled by Method G52 and the methyl ester removed by Method G4. L-alanine-O-*t*-butyl ester was coupled by Method G3. The *t*-butyl ester was removed by Method G11 and the completed compound was purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

**Method S104**

4-amino-2,6-dichlorophenol was Boc protected by Method G44 and the phenol converted to its corresponding triflate by Method G45. The triflate was converted to a carboxylic acid methyl ester by Method G46. The Boc aniline was converted to the phenol by Method G47 and then the methyl ester removed by Method G48. The resulting carboxylic acid was then converted to its allyl ester by Method G49 (Compound G). 3-hydroxymandelic acid was converted to its corresponding alcohol by Method G25 and coupled to the phenol (Compound G) by Method G26. And the allyl ester removed by Method G50. The resulting benzoic acid was coupled to commercially available L-asparagine-O-*t*-butyl ester by Method G3. The *t*-butyl ester was removed by Method G11 without TES. The completed molecule was then concentrated *in vacuo*, purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

**Method S105**

4-amino-2,6-dichlorophenol was Boc protected by Method G44 and the phenol converted to its corresponding triflate by Method G45. The triflate was converted to a carboxylic acid methyl ester by Method G46. The Boc aniline was converted to the phenol by Method G47 and then the methyl ester removed by Method G48. The resulting carboxylic acid was then converted to its allyl ester by Method G49 (Compound G). 1,3-dibromopropane was coupled to the phenol (Compound G) by Method G51. The 3-hydroxy phenol was coupled by Method G52 and the methyl ester removed by Method G4. The allyl ester removed by Method G50. The resulting benzoic acid was coupled to commercially available L-asparagine-O-*t*-butyl ester by Method G3. The *t*-butyl ester was removed by Method G11 without TES. The completed molecule was then concentrated *in vacuo*,

purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

#### Method S106

4-amino-2, 6-dichlorophenol was Boc protected by Method G44 and the phenol converted to its corresponding triflate by Method G45. The triflate was converted to a carboxylic acid methyl ester by Method G46. The Boc aniline was converted to the phenol by Method G47 and then the methyl ester removed by Method G48. The resulting carboxylic acid was then converted to its allyl ester by Method G49 (Compound G). 1, 2-dibromopropane was coupled to the phenol (Compound G) by Method G51. The 3-hydroxy phenol was coupled by Method G52 and the methyl ester removed by Method G4. The allyl ester removed by Method G50. The resulting benzoic acid was coupled to commercially available L-asparagine-O-*t*-butyl ester by Method G3. The *t*-butyl ester was removed by Method G11 without TES. The completed molecule was then concentrated *in vacuo*, purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

#### Method S107

4-amino-2, 6-dichlorophenol was Boc protected by Method G44 and the phenol converted to its corresponding triflate by Method G45. The triflate was converted to a carboxylic acid methyl ester by Method G46. The Boc aniline was converted to the phenol by Method G47 and then the methyl ester removed by Method G48. The resulting carboxylic acid was then converted to its allyl ester by Method G49 (Compound G). 1, 2-dibromopropane was coupled to the phenol (Compound G) by Method G51. The 3-hydroxy phenol was coupled by Method G52 and the methyl ester removed by Method G4. The allyl ester removed by Method G50. The resulting benzoic acid was coupled to commercially available L-alanine-O-*t*-butyl ester by Method G3. The *t*-butyl ester was removed by Method G11 without TES. The completed molecule was then concentrated *in vacuo*, purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

#### Method S108

4-amino-2, 6-dichlorophenol was Boc protected by Method G44 and the phenol converted to its corresponding triflate by Method G45. The triflate was converted to a carboxylic acid methyl ester by Method G46. The Boc aniline was converted to the iodide by Method G54 and then the methyl ester removed by Method G55. This benzoic acid was then coupled to L-asparagine-O-*t*-butyl ester by Method G3. 3-hydroxybenzoic acid was converted to the hydroxamate by Method G56. The hydroxyl was protected as the *t*-butyl ether by Method G10 and the hydroxamate converted to the aldehyde by Method G57. The aldehyde was coupled to ethynyl magnesium bromide by Method G58 and the resulting product coupled to the above aryl iodide by Method G59. The alkyne was then reduced to the alkane by Method G60. The *t*-butyl ester and ether were removed by Method G11 without TES. The completed molecule was then concentrated *in vacuo*,

purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

#### Method S109

4-amino-2, 6-dichlorophenol was Boc protected by Method G44 and the phenol converted to its corresponding triflate by Method G45. The triflate was converted to a carboxylic acid methyl ester by Method G46. The Boc aniline was converted to the iodide by Method G54 and then the methyl ester removed by Method G55. This benzoic acid was then coupled to L-asparagine-O-*t*-butyl ester by Method G3. 3-hydroxybenzoic acid was converted to the hydroxamate by Method G56. The hydroxyl was protected as the *t*-butyl ether by Method G10 and the hydroxamate converted to the aldehyde by Method G57. The aldehyde was coupled to ethynyl magnesium bromide by Method G58 and the resulting product coupled to the above aryl iodide by Method G59. The alkyne was then reduced to the alkane by Method G60. The *t*-butyl ester and ether were removed by Method G11. The completed molecule was then concentrated *in vacuo*, purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

#### Method S110

3, 5-dimethyl-4-hydroxybenzaldehyde was coupled to ethynyl magnesium bromide by Method G58 and this product was coupled to 3-iodoanisole by Method G59. The alkynol was hydrogenated to the alkane by Method G38 except the product was purified by silica flash chromatography (3/6/1 hexane/DCM/Et<sub>2</sub>O) to provide pure aryl alcohol. The alcohol was silyl protected by Method G18. The phenol converted to its corresponding triflate by Method G45. The triflate was converted to a carboxylic acid methyl ester by Method G46. The methyl ether and ester were removed by Method G55. The acid was coupled to L-asparagine-O-*t*-butyl ester by Method G3. The *t*-butyl ester was removed by Method G11 without TES and the silyl ether was removed in the same reaction by adding 3 equivalents of TBAF. The completed molecule was then concentrated *in vacuo*, purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

#### Method S111

4-amino-2, 6-dichlorophenol was Boc protected by Method G44 and the phenol converted to its corresponding triflate by Method G45. The triflate was converted to a carboxylic acid methyl ester by Method G46. The Boc aniline was converted to the iodide by Method G54 and then the methyl ester removed by Method G55. This benzoic acid was then coupled to L-asparagine-O-*t*-butyl ester by Method G3. 3'-Hydroxyacetophenone was converted to the *t*-butyl ether using Method G10. G58 resulting alkyne coupled to the aryl iodide using Method G59. The alkyne was hydrogenated to the alkane using Method G60. Reductive removal of the benzylic alcohol, as well as cleavage of the *t*-butyl ether and ester groups was accomplished using Method G11 (containing excess TES). The crude product was isolated by concentrating *in vacuo*, purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

**Method S112**

2, 6-Dichloro-4-methyl phenol was converted to the triflate according to Method G45. This triflate was carbonylated to the methyl ester using Method G46 and then converted to the aldehyde by Method G84. The aldehyde was treated with ethynyl magnesium bromide by Method G58 and the resulting alkyne coupled to 3-iodophenol using Method G59. The alkyne was hydrogenated to the alkane using Method G60 and the methyl ester was cleaved using Method G55. The resulting carboxylic acid was coupled to L-asparagine-O-*t*-butyl ester using Method G3. Cleavage of the *t*-butyl ester group was accomplished using Method G11 (containing no TES). The crude product was isolated by concentrating *in vacuo*, purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

**Method S113**

2, 6-Dichloro-4-methyl phenol was converted to the triflate according to Method G45. This triflate was carbonylated to the methyl ester using Method G46 and then converted to the aldehyde by Method G84. 3-Iodophenol was silylated according to Method G18 to give O-*t*-butyl-dimethylsilyl-3-iodophenol. The aldehyde was treated with ethynyl magnesium bromide by Method G58 and the resulting alkyne coupled to O-*t*-butyl-dimethylsilyl-3-iodophenol using Method G59. The alkyne was hydrogenated to the alkane using Method G60. The resulting alcohol was converted to the methyl ether by Method G85 and the methyl ester was cleaved using Method G55. The resulting carboxylic acid was coupled to L- asparagine O-*t*-butyl ester using Method G3. The *t*-butyl ester was removed by Method G11 without TES and the silyl ether was removed in the same reaction by adding 3 equivalents of TBAF. The crude product was isolated by concentrating *in vacuo*, purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

**Method S114**

2, 6-Dichloro-4-methyl phenol was converted to the triflate according to Method G45. This triflate was carbonylated to the methyl ester using Method G46 and then converted to the aldehyde by Method G84. 3-Iodophenol was silylated according to Method G18 to give O-*t*-butyl-dimethylsilyl-3-iodophenol. The aldehyde was treated with ethynyl magnesium bromide by Method G58 and the resulting alkyne coupled to O-*t*-butyl-dimethylsilyl-3-iodophenol using Method G59. The alkyne was hydrogenated to the alkane using Method G60 and the methyl ester was cleaved using Method G55. The resulting carboxylic acid was coupled to N- $\beta$ -alloc-L- $\alpha$ ,  $\beta$ -diaminopropionic acid methyl ester using Method G3 (adding an equivalent of DIPEA). The silyl ether was removed by Method G11 without TES with the addition of 3 equivalents of TBAF. The methyl ester was saponified using Method G4. The crude product was isolated by concentrating *in vacuo*, purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.



**Method S115**

2, 6-Dichloro-4-methyl phenol was converted to the triflate according to Method G45. This triflate was carbonylated to the methyl ester using Method G46 and then converted to the aldehyde by Method G84. 3-Iodophenol was silylated according to Method G18 to give O-*t*-butyl-dimethylsilyl-3-iodophenol. The aldehyde was treated with ethynyl magnesium bromide by Method G58 and the resulting alkyne coupled to O-*t*-butyl-dimethylsilyl-3-iodophenol using Method G59. The alkyne was hydrogenated to the alkane using Method G60 and the methyl ester was cleaved using Method G55. The resulting carboxylic acid was coupled to N- $\epsilon$ -Boc-L-lysine methyl ester using Method G3 (adding an equivalent of DIPEA). The methyl ester was saponified using Method G4 and the Boc group was removed by Method G11 without TES and the silyl ether was removed in the same reaction by adding 3 equivalents of TBAF. The crude product was isolated by concentrating *in vacuo*, purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

**Method S116**

3-Hydroxybenzoic acid was converted to the N-methoxy-N-methylamide using Method G56. The hydroxyl was protected as the *t*-butyl ether by Method G10. The N-methoxy-N-methylamide was reduced to the aldehyde by Method G57. The aldehyde was treated with ethynyl magnesium bromide by Method G58. 4-amino-2, 6-dichlorophenol was Boc protected by Method G44 and the phenol converted to its corresponding triflate by Method G45. The triflate was converted to a carboxylic acid methyl ester by Method G46. The Boc aniline was converted to the iodide by Method G54. The resulting aryl iodide was then coupled to the above alkyne by Method G59. The alkyne was hydrogenated to the alkane using Method G60. The methyl ester was cleaved using Method G55. The carboxylic acid was coupled to N- $\beta$ -alloc-L- $\alpha$ ,  $\beta$ -diaminopropionic acid methyl ester using Method G3 (adding an equivalent of DIPEA). The methyl ester was saponified using Method G4. The *t*-butyl ether was cleaved by using Method G11 (containing no TES). The crude product was isolated by concentrating *in vacuo*, purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

**Method S117**

3-Hydroxybenzoic acid was converted to the N-methoxy-N-methylamide using Method G56. The hydroxyl was protected as the *t*-butyl ether by Method G10. The N-methoxy-N-methylamide was reduced to the aldehyde by Method G57. The aldehyde was treated with ethynyl magnesium bromide by Method G58. 4-amino-2, 6-dichlorophenol was Boc protected by Method G44 and the phenol converted to its corresponding triflate by Method G45. The triflate was converted to a carboxylic acid methyl ester by Method G46. The Boc aniline was converted to the iodide by Method G54. The resulting aryl iodide was then coupled to the above alkyne by Method G59. The alkyne was hydrogenated to the alkane using Method G60. The resulting alcohol was converted to the methyl ether by Method G85 and the methyl ester was cleaved using Method G55. The resulting carboxylic acid was coupled to L-asparagine-O-*t*-butyl ester using Method G3.

Cleavage of the *t*-butyl ester group was accomplished using Method G11 (containing no TES). The crude product was isolated by concentrating *in vacuo*, purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

**Method S118**

5           4-amino-2, 6-dichlorophenol was Boc protected by Method G44 and the phenol converted to its corresponding triflate by Method G45. The triflate was converted to a carboxylic acid methyl ester by Method G46. The Boc aniline was converted to the iodide by Method G54. 3-Chlorobenzaldehyde was treated with ethynyl magnesium bromide by Method G58, and the resulting alkyne coupled to the above aryl iodide by Method G59. The alkyne was hydrogenated to  
10 the alkane using Method G60. The methyl ester was cleaved using Method G55. The carboxylic acid was coupled to N- $\beta$ -alloc-L- $\alpha$ ,  $\beta$ -diaminopropionic acid methyl ester using Method G3 (adding an equivalent of DIPEA). The methyl ester was saponified using Method G4. The crude product was isolated by concentrating *in vacuo*, purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

15           **Method S119**

          4-amino-2, 6-dichlorophenol was Boc protected by Method G44 and the phenol converted to its corresponding triflate by Method G45. The triflate was converted to a carboxylic acid methyl ester by Method G46. The Boc aniline was converted to the iodide by Method G54. 3-Chlorobenzaldehyde was treated with ethynyl magnesium bromide by Method G58, and the  
20 resulting alkyne coupled to the above aryl iodide by Method G59. The alkyne was hydrogenated to the alkane using Method G60. The methyl ester was removed by Method G55 and the resulting acid coupled by Method G20 to commercially available  $\beta$ -Boc-diaminopropionic acid methyl ester. The Boc group was removed by Method G1 and thiophene 2-carboxylic acid was coupled by Method G3. After saponification, Method G4, the molecule was purified by reverse phase HPLC, verified by  
25 electrospray mass spectrometry and lyophilized to a powder.

**Method S120**

          3-Hydroxybenzoic acid was converted to the N-methoxy-N-methylamide using Method G56. The hydroxyl was protected as the *t*-butyl ether by Method G10. The N-methoxy-N-methylamide was reduced to the aldehyde by Method G57. The aldehyde was treated with ethynyl  
30 magnesium bromide by Method G58. 4-amino-2, 6-dichlorophenol was Boc protected by Method G44 and the phenol converted to its corresponding triflate by Method G45. The triflate was converted to a carboxylic acid methyl ester by Method G46. The Boc aniline was converted to the iodide by Method G54. The resulting aryl iodide was then coupled to the above alkyne by Method G59. The alkyne was hydrogenated to the alkane using Method G60. The methyl ester was removed  
35 by Method G55 and the resulting acid coupled by Method G20 to commercially available  $\beta$ -Boc-diaminopropionic acid methyl ester. The Boc group was removed by Method G1 and thiophene 2-carboxylic acid was coupled by Method G3. After saponification, Method G4, the molecule was

purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

#### Method S121

4-amino-2, 6-dichlorophenol was Boc protected by Method G44 and the phenol converted to its corresponding triflate by Method G45. The triflate was converted to a carboxylic acid methyl ester by Method G46. The Boc aniline was converted to the iodide by Method G54. 3-Chlorobenzaldehyde was treated with ethynyl magnesium bromide by Method G58, and the resulting alkyne coupled to the above aryl iodide by Method G59. The alkyne was hydrogenated to the alkane using Method G60. The methyl ester was removed by Method G55 and the resulting acid coupled by Method G20 to commercially available N- $\epsilon$ -Boc-L-lysine methyl ester using Method G3 (adding an equivalent of DIPEA). The methyl ester was saponified using Method G4 and the Boc group was removed by Method G11 (containing no TES). The crude product was isolated by concentrating *in vacuo*, purified by reverse phase HPLC, verified by electrospray mass spectrometry and lyophilized to a powder.

#### Method S122

Compounds were synthesized using standard Fmoc solid phase methods on commercially available Fmoc- glycine- Wang resin (0.5 mmol/g). The Fmoc group was cleaved by Method G19. The  $\alpha$  glycine  $\alpha$  carbon was alkylated with the appropriate commercially available bromide or chloride by Method G36 resulting in the corresponding racemic amino acid. Compound E was coupled to the resin by Method G37 and the completed molecule was worked up by Method G21.

#### Method S123

Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L-Aspartic acid (allyl)- p- alkoxybenzyl alcohol resin (0.5 mmol/g). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc- $\beta$ -Allyl-L-aspartic acid. The Fmoc group was cleaved by Method G19. Compound E was coupled to the resin by Method G37. The Allyl group was removed by Method G39. The appropriate aniline (R) was coupled by Method G40. The completed molecule was worked up by Method G21.

#### Method S124

Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L-aspartic acid (allyl)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- asp(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc- $\beta$ -Allyl-L-aspartic acid. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The allyl group was removed by Method G39. The appropriate amine (R) was coupled by Method G41. The completed molecule was worked up by Method G21.

#### Method S125

Compounds were synthesized using standard Fmoc solid phase methods on Fmoc- L-glutamic acid (allyl)- p- alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc- L- glu(alloc)- Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc- $\beta$ -Allyl-L-glutamic

acid. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The allyl group was removed by Method G39. The appropriate amine (R) was coupled by Method G41. The completed molecule was worked up by Method G21.

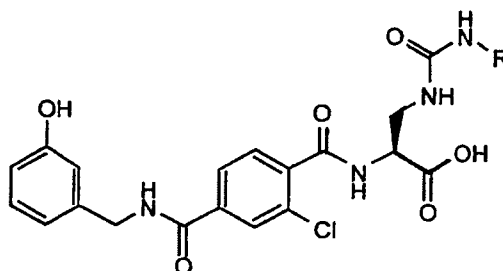
#### Method S126

- 5        Compounds were synthesized using standard Fmoc solid phase methods on N- $\alpha$ -Fmoc-O-trityl-L-serine-p-alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc-L-Ser(trityl)-Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-O-trityl-L-serine. The Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The trityl group was removed by Method G72. The appropriate amine (R) was coupled by Method
- 10       G73. The completed molecule was worked up by Method G21.

#### Method S127

- Compounds were synthesized using standard Fmoc solid phase methods on N- $\alpha$ -Fmoc-O-trityl-L-threonine-p-alkoxybenzyl alcohol resin (0.5 mmol/g) (Fmoc-L-thr(trityl)-Wang resin). The resin was made by Method G34 using commercially available N- $\alpha$ -Fmoc-O-trityl-L-serine. The
- 15       Fmoc group was cleaved by Method G19. Compound C, Method G13, was coupled by Method G20. The trityl group was removed by Method G72. The appropriate amine (R) was coupled by Method G73. The completed molecule was worked up by Method G21.

#### Examples 1-39



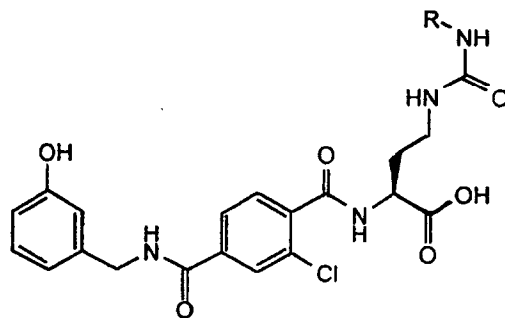
- 20       Examples 1-39 were synthesized by Method S1.

Example #	R group
1	2-isopropylphenyl isocyanate
2	phenethyl isocyanate
3	1-naphthyl isocyanate
25 4	(S)-(-)- $\alpha$ -methylbenzyl isocyanate
5	cyclohexyl isocyanate
6	ethoxycarbonyl isocyanate
7	isopropyl isocyanate
8	trans-2-phenylcyclopropyl isocyanate
30 9	1-adamantyl isocyanate
10	phenyl isocyanate
11	4-(methylthio)phenyl isocyanate

- 12 3-(methylthio)phenyl isocyanate  
13 3-ethoxycarbonylphenyl isocyanate  
14 4-ethoxycarbonylphenyl isocyanate  
15 4-fluorophenyl isocyanate  
5 16 2-fluorophenyl isocyanate  
17 2-(trifluoromethoxy)phenyl isocyanate  
18 3-fluorophenyl isocyanate  
19 3-bromophenyl isocyanate  
20 4-methoxyphenyl isocyanate  
10 21 4-isopropylphenyl isocyanate  
22 3-(2-hydroxy)ethyl phenyl isocyanate  
23 4-ethylphenyl isocyanate  
24 2-nitrophenyl isocyanate  
25 3-nitrophenyl isocyanate  
15 26 4-nitrophenyl isocyanate  
27 3-cyanophenyl isocyanate  
28 4-trifluoromethyl isocyanate  
29 3-trifluoromethyl isocyanate  
30 2-trifluoromethyl isocyanate  
20 31 3-methylphenyl isocyanate  
32 4-chlorophenyl isocyanate  
33 3-chlorophenyl isocyanate  
34 3-chloro-4-methylphenyl isocyanate  
35 3-ethylphenyl isocyanate  
25 36 allyl isocyanate  
37 (S)-(-)- $\alpha$ -methylbenzyl isocyanate  
38 cyclohexyl isocyanate  
39 trans-2-phenylcyclopropyl isocyanate

Examples 40-43

30

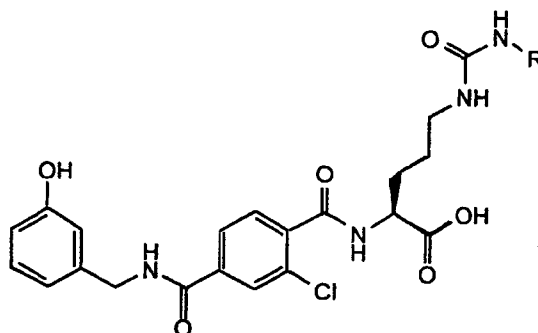


115

Examples 40-43 were synthesized by Method S2.

Example #	R group
40	benzyl isocyanate
41	ethoxycarbonyl isocyanate
5 42	2-chloro-6-methylphenyl isocyanate
43	ethoxycarbonyl isocyanate

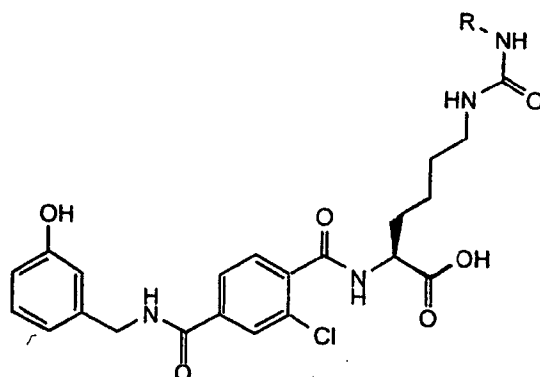
Examples 44-62



10 Examples 44-62 were synthesized by Method S3.

Example #	R group
44	phenethyl isocyanate
45	isopropyl isocyanate
46	cyclohexyl isocyanate
15 47	3-ethoxycarbonylphenyl isocyanate
48	4-ethoxycarbonylphenyl isocyanate
49	4-fluorophenyl isocyanate
50	2-fluorophenyl isocyanate
51	3-fluorophenyl isocyanate
20 52	4-methoxyphenyl isocyanate
53	4-isopropylphenyl isocyanate
54	3-(2-hydroxyethyl)phenyl isocyanate
55	2-nitrophenyl isocyanate
56	4-nitrophenyl isocyanate
25 57	3-cyanophenyl isocyanate
58	3-methylphenyl isocyanate
59	4-chlorophenyl isocyanate
60	3-chloro-4-methylphenyl isocyanate
61	2-chloro-6-methylphenyl isocyanate
30 62	4-ethylphenyl isocyanate

## Examples 63-71

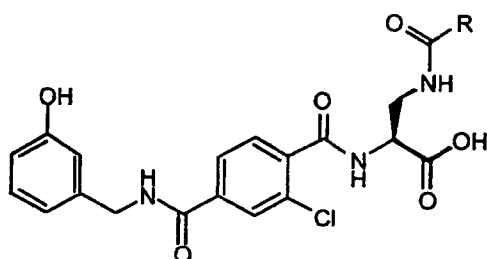


Examples 63-71 were synthesized by Method S4.

Example #	R group
5 63	phenethyl isocyanate
64	isopropyl isocyanate
65	benzyl isocyanate
66	propyl isocyanate
67	ethoxycarbonyl isocyanate
10 68	ethyl 2-isocyanato-4-methylvalerate
69	(S)-(-)-α-methylbenzyl isocyanate
70	benzensulfonyl isocyanate
71	benzyl isocyanate

15

## Examples 72-95



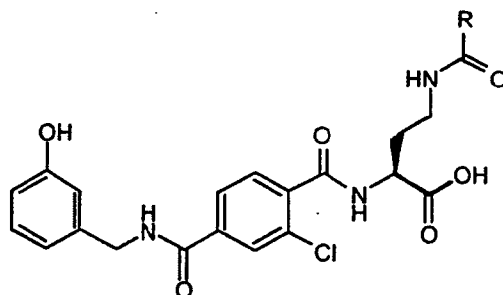
Examples 72-95 were synthesized by Method S5.

Example #	R group
20 72	3-methylindene-2-carboxylic acid
73	3-methylbenzofuran-2-carboxylic acid
74	4-Oxo-4, 5, 6, 7-tetrahydro-benzofuran-3-carboxylic acid
75	1, 2, 5-Trimethyl-1H-pyrrole-3-carboxylic acid
76	4-Methyl-[1, 2, 3]thiadiazole-5-carboxylic acid

77	4-Phenyl-[1, 2, 3]thiadiazole-5-carboxylic acid
78	3-chloro-2thiophenecarboxylic acid
79	3, 5-Dimethyl-isoxazole-4-carboxylic acid
80	3-methyl-2-furoic acid
5 81	3-bromothiophene-2-carboxylic acid
82	2-furoic acid
83	3-furoic acid
84	2-thiophene carboxylic acid
85	3- thiophenecarboxylic acid
10 86	5- chloro 2- thiophene carboxylic acid
87	5- bromo 2- thiophene carboxylic acid
88	indole 5- carboxylic acid
89	indole 4- carboxylic acid
90	indole 6- carboxylic acid
15 91	benzoic acid
92	cyclohexyl carboxylic acid
93	acetic acid
94	isonipecotic acid
95	pipecolinic acid

20

## Examples 96-113



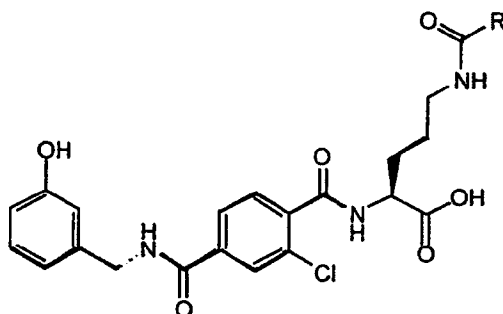
Examples 96-113 were synthesized by Method S6.

Example #	R group
96	3, 4, 5-trimethoxybenzoic acid
25 97	propionic acid
98	cyclopropyl carboxylic acid
99	trimethyl acetic acid
100	1, 2, 5-Trimethyl-1H-pyrrole-3-carboxylic acid
101	3-Chloro-4-methanesulfonyl-thiophene-2-carboxylic acid
30 102	4-Methyl-[1, 2, 3]thiadiazole-5-carboxylic acid
103	4-Phenyl-[1, 2, 3]thiadiazole-5-carboxylic acid



	104	4-Bromo-2-ethyl-5-methyl-2H-pyrazole-3-carboxylic acid
	105	3-chlorothiophene-2-carboxylic acid
	106	3, 5-Dimethyl-isoxazole-4-carboxylic acid
	107	5-Methyl-2-phenyl-2H-[1, 2, 3]triazole-4-carboxylic acid
5	108	3-methyl-2-furoic acid
	109	3-bromothiophene-2-carboxylic acid
	110	benzoic acid
	111	cyclohexyl carboxylic acid
	112	acetic acid
10	113	none

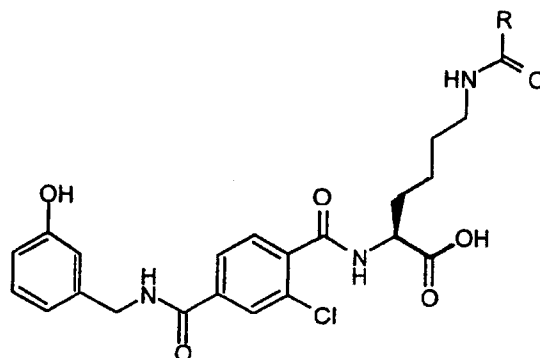
## Examples 114-126



Examples 114-126 were synthesized by Method S7.

Example #	R group
15 114	trimethyl acetic acid
115	3-Chloro-benzo[b]thiophene-2-carboxylic acid
116	3-chlorothiophene-2-carboxylic acid
117	3, 5-Dimethyl-isoxazole-4-carboxylic acid
118	3-bromothiophene-2-carboxylic acid
20 119	3-methylindene-2-carboxylic acid
120	4-Oxo-4, 5, 6, 7-tetrahydro-benzofuran-3-carboxylic acid
121	3-Chloro-4-methanesulfonyl-thiophene-2-carboxylic acid
122	4-Methyl-[1, 2, 3]thiadiazole-5-carboxylic acid
123	4-Bromo-2-ethyl-5-methyl-2H-pyrazole-3-carboxylic acid
25 124	benzoic acid
125	cyclohexane carboxylic acid
126	acetic acid

## Examples 127-144



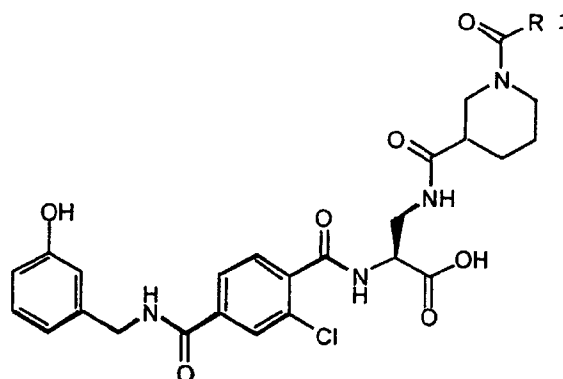
Examples 127-144 were synthesized by Method S8.

Example #	R group
5 127	3, 4, 5-trimethoxybenzoic acid
128	isovaleric acid
129	propionic acid
130	cyclopropyl carboxylic acid
131	4-acetyl-3, 5-dimethyl-2-pyrrolecarboxylic acid
10 132	3-methylindene-2-carboxylic acid
133	4-Oxo-4, 5, 6, 7-tetrahydro-benzofuran-3-carboxylic acid
134	1, 2, 5-Trimethyl-1H-pyrrole-3-carboxylic acid
135	3-Chloro-4-methanesulfonyl-thiophene-2-carboxylic acid
136	4-Methyl-[1, 2, 3]thiadiazole-5-carboxylic acid
15 137	4-Phenyl-[1, 2, 3]thiadiazole-5-carboxylic acid
138	4-Bromo-2-ethyl-5-methyl-2H-pyrazole-3-carboxylic acid
139	3-chlorothiophene-2-carboxylic acid
140	3, 5-Dimethyl-isoxazole-4-carboxylic acid
141	5-Methyl-2-phenyl-2H-[1, 2, 3]triazole-4-carboxylic acid
20 142	3-bromothiophene-2-carboxylic acid
143	benzoic acid
144	cyclohexyl carboxylic acid

25

30

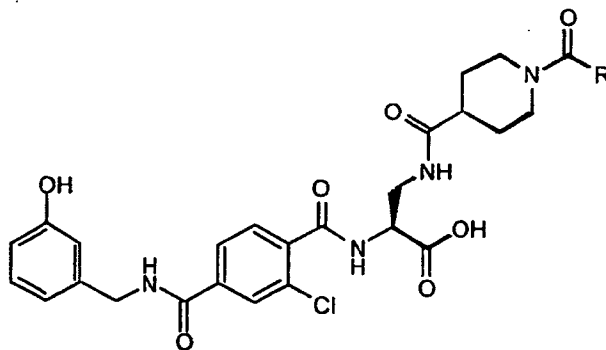
## Examples 145-147



Examples 145-147 were synthesized by Method S9.

Example #	R group
145	propionic acid
146	acetic acid
147	none

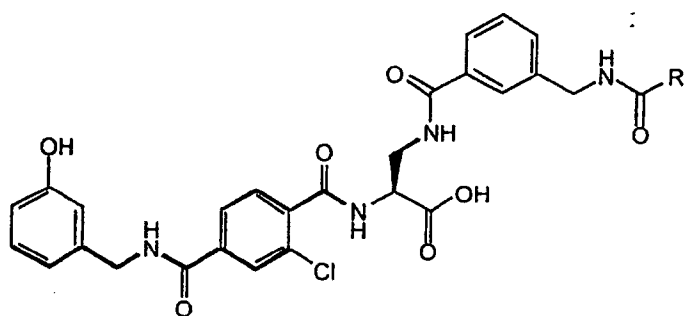
## Examples 148-150



Examples 148-150 were synthesized by Method S10.

Example #	R group
148	propionic acid
149	butyric acid
150	acetic acid

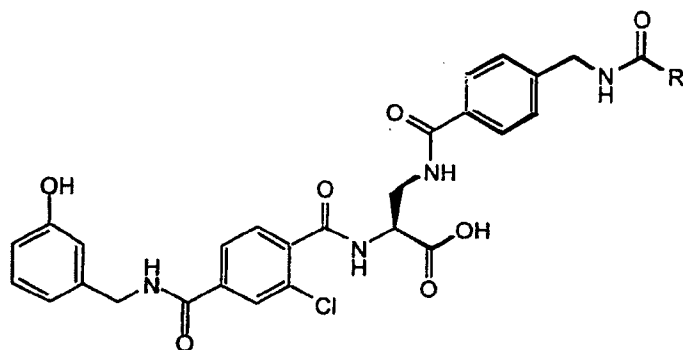
## Examples 151-154



Examples 151-154 were synthesized by Method S11.

Example #	R group
151	propionic acid
152	butyric acid
153	acetic acid
154	none

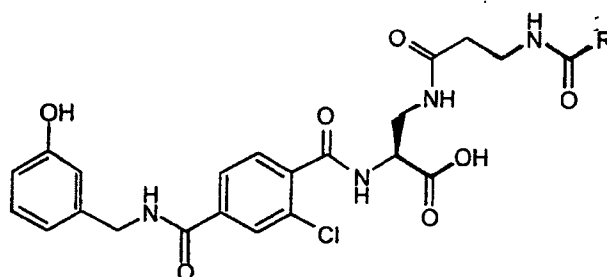
## Examples 155-158



Examples 155-158 were synthesized by Method S12.

Example #	R group
155	propionic acid
156	butyric acid
157	acetic acid
158	none

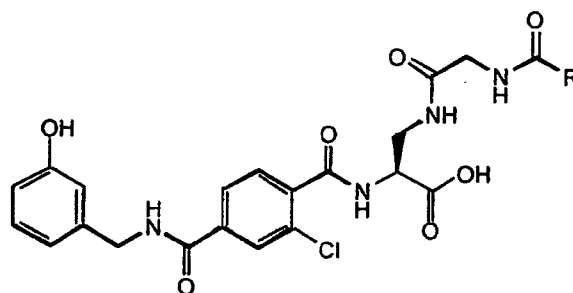
## Examples 159-161



Examples 159-161 were synthesized by Method S13.

Example #	R group
159	propionic acid
160	acetic acid
161	none

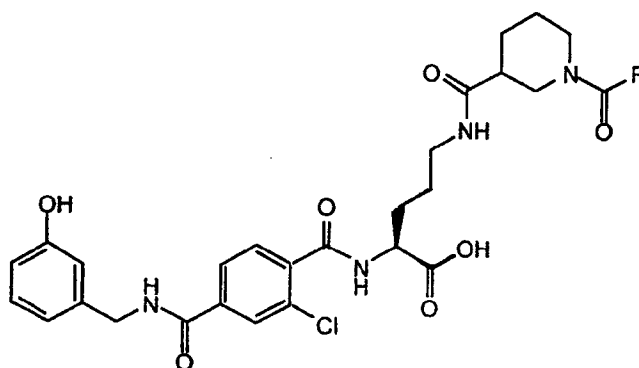
## Examples 162-163



Examples 162-163 were synthesized by Method S14.

Example #	R group
162	acetic acid
163	none

## Examples 164-167



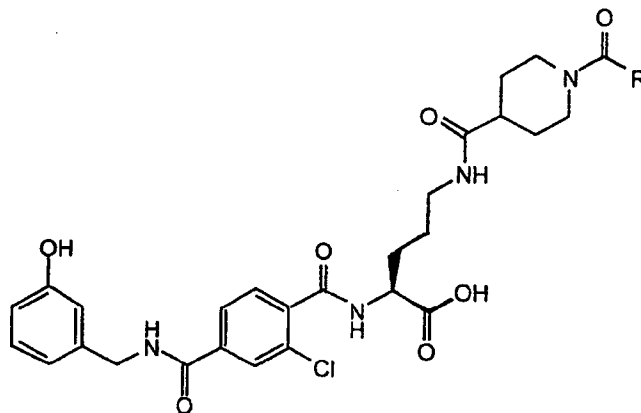
Examples 164-167 were synthesized by Method S15.

Example #	R group
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164	propionic acid
165	butyric acid
166	acetic acid
167	none

5

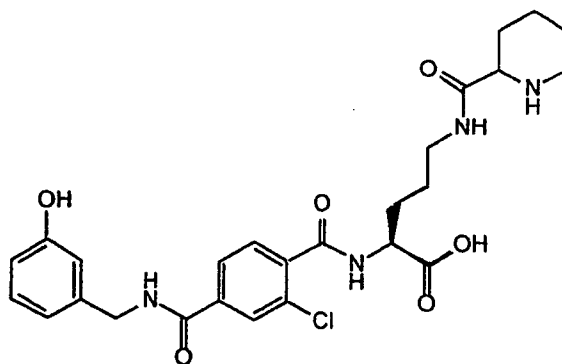
## Examples 168-171



Examples 168-171 were synthesized by Method S16.

	Example #	R group
10	168	propionic acid
	169	butyric acid
	170	acetic acid
	171	none

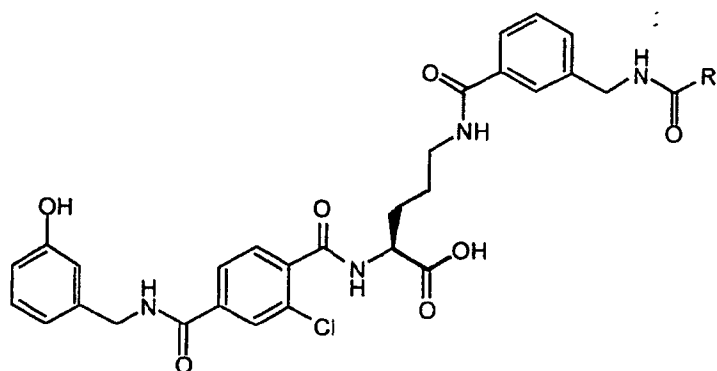
## Example 172



15 Example 172 was synthesized by Method S17.

20

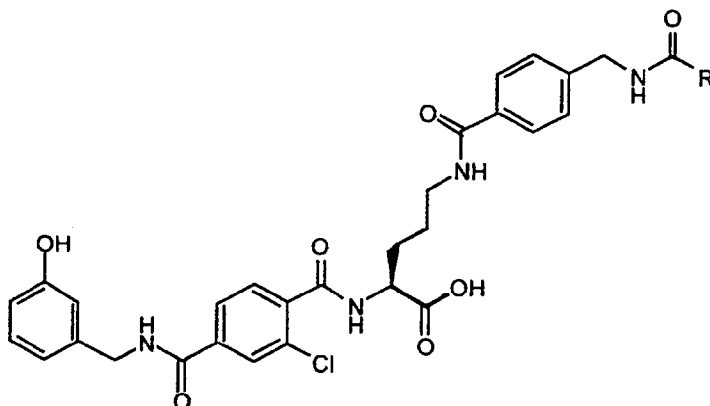
## Examples 173-176



Examples 173-176 were synthesized by Method S18.

Example #	R group
173	propionic acid
174	butyric acid
175	acetic acid
176	none

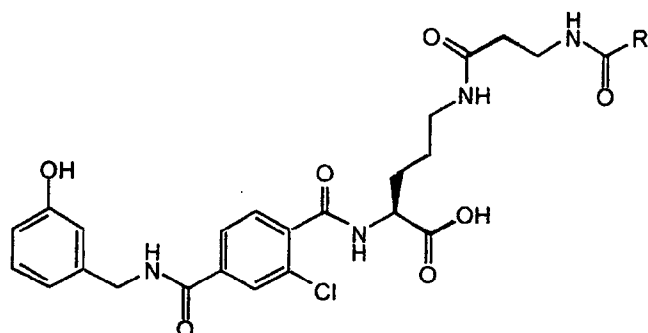
## Examples 177-180



Examples 177-180 were synthesized by Method S19.

Example #	R group
177	propionic acid
178	butyric acid
179	acetic acid
180	none

## Examples 181-184

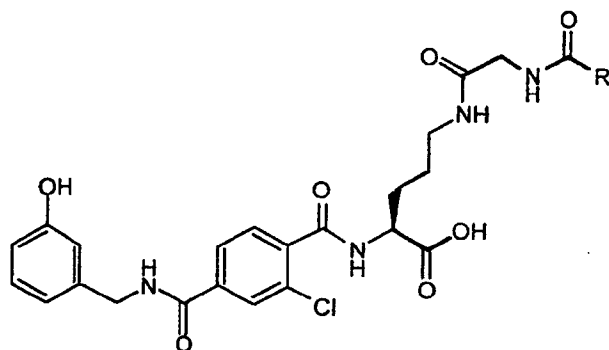


Examples 181-184 were synthesized by Method S20.

5	Example #	R group
	181	propionic acid
	182	butyric acid
	183	acetic acid
	184	none

10

## Examples 185-188



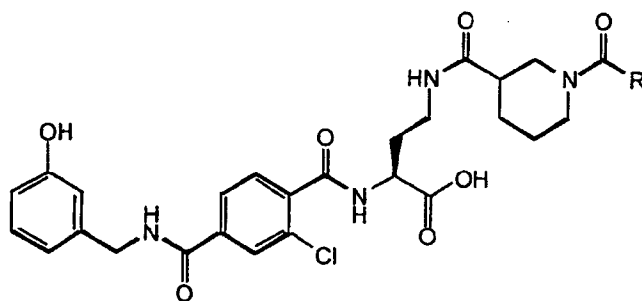
Examples 185-188 were synthesized by Method S21.

	Example #	R group
15	185	propionic acid
	186	butyric acid
	187	acetic acid
	188	none

20



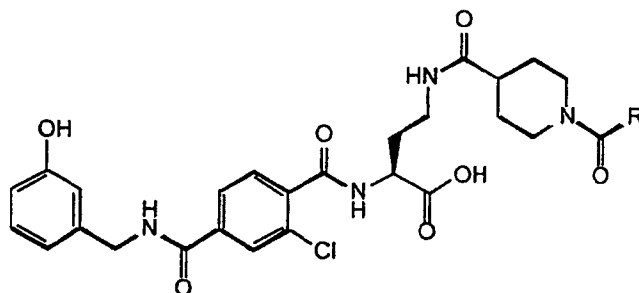
## Examples 189-192



5     Examples 189-192 were synthesized by Method S22.

Example #	R group
189	propionic acid
190	butyric acid
191	acetic acid
10     192	none

## Examples 193-196

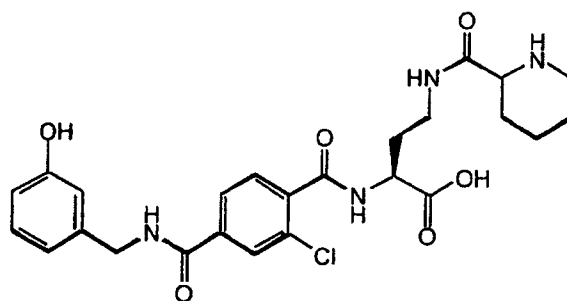


15     Examples 193-196 were synthesized by Method S23.

Example #	R group
193	propionic acid
194	butyric acid
195	acetic acid
20     196	none

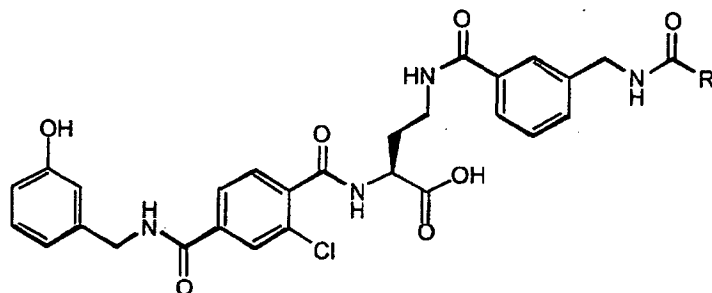
25

## Example 197



Example 197 was synthesized by Method S24.

## Examples 198-201



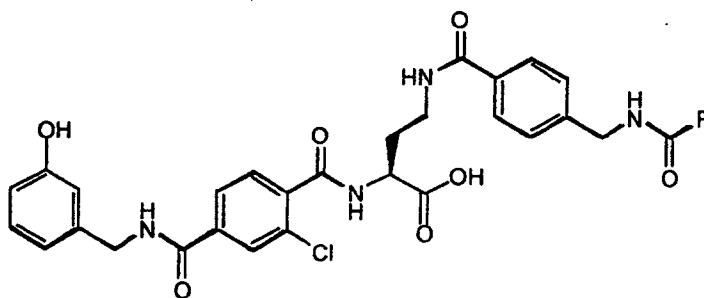
5

Examples 198-201 were synthesized by Method S25.

Example #	R group
198	propionic acid
199	butyric acid
200	acetic acid
201	none

10

## Examples 202-205

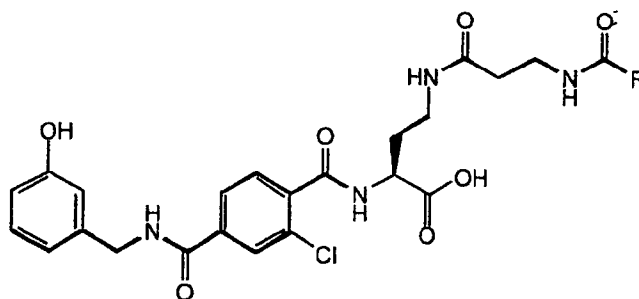


Examples 202-205 were synthesized by Method S26.

Example #	R group
202	propionic acid
203	butyric acid
204	acetic acid
205	none

15

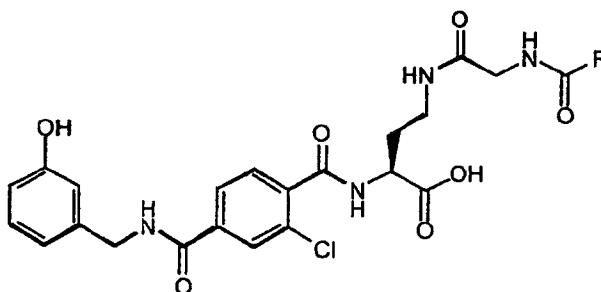
## Examples 206-209



Examples 206-209 were synthesized by Method S27.

Example #	R group
206	propionic acid
207	butyric acid
208	acetic acid
209	none

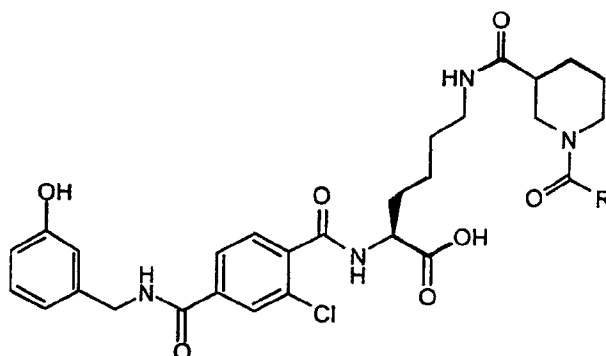
## Examples 210-213



Examples 210-213 were synthesized by Method S28.

Example #	R group
210	propionic acid
211	butyric acid
212	acetic acid
213	none

### Examples 214-217

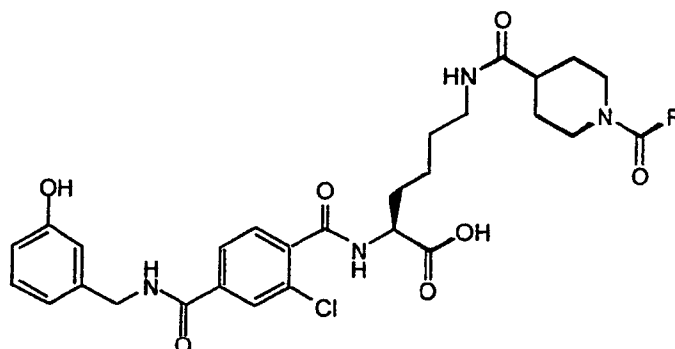


Examples 214-217 were synthesized by Method S29.

5	Example #	R group
	214	propionic acid
	215	butyric acid
	216	acetic acid
	217	none

10

### Examples 218-221

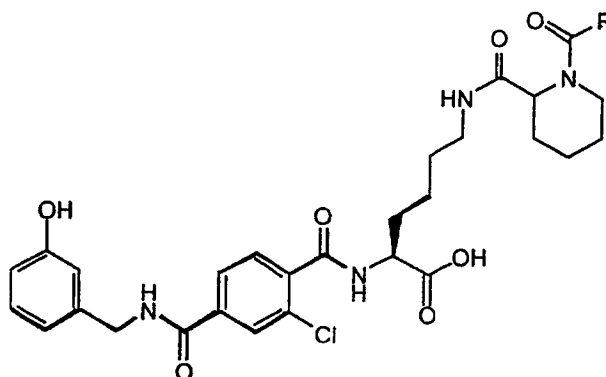


Examples 218-221 were synthesized by Method S30.

15	Example #	R group
	218	propionic acid
	219	butyric acid
	220	acetic acid
	221	none

20

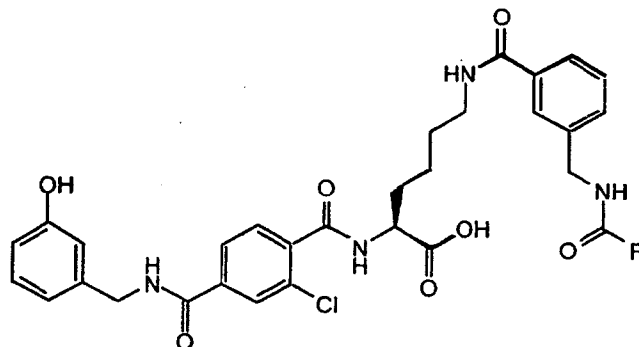
## Examples 222-223



Examples 222-223 were synthesized by Method S31.

Example #	R group
5 222	acetic acid
223	none

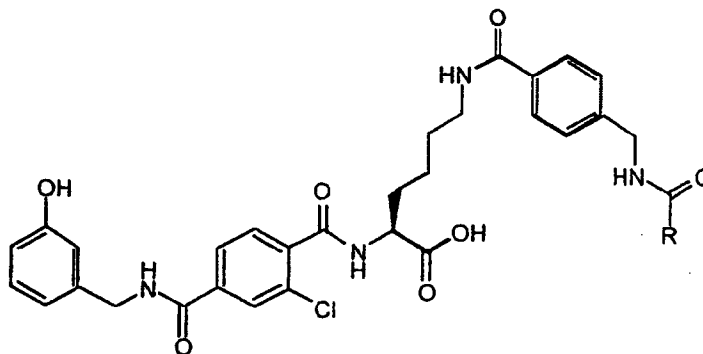
## Examples 224-225



Examples 224-225 were synthesized by Method S32.

Example #	R group
10 224	propionic acid
225	none

## Examples 226-227

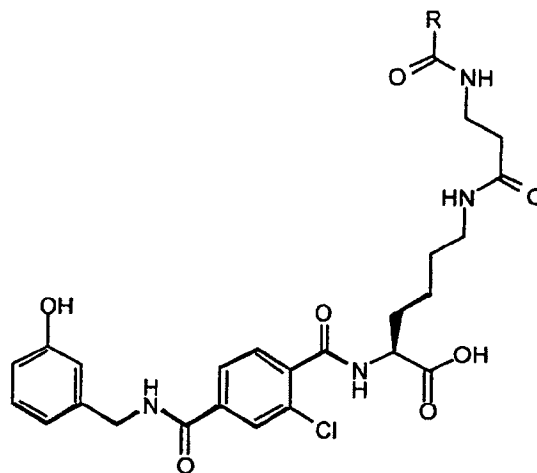


Examples 226-227 were synthesized by Method S33.

Example #	R group
226	acetic acid
227	none

5

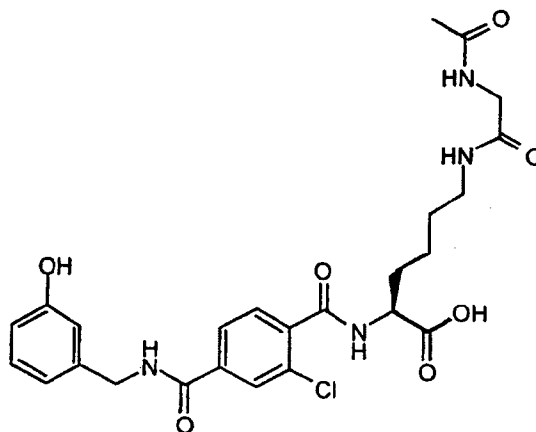
Examples 228-229



Examples 228-229 were synthesized by Method S34.

10	Example #	R group
	228	acetic acid
	229	none

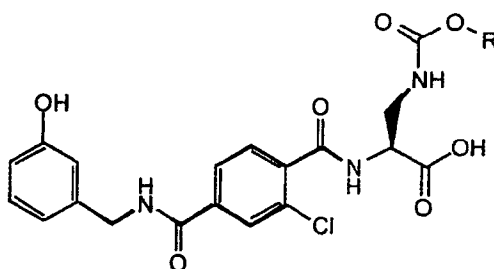
Example 230



15

Example 230 was synthesized by Method S35.

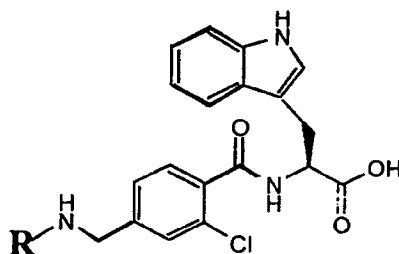
## Examples 231-237



Examples 231-237 were synthesized by Method S36.

Example #	R group
5 231	propyl chloroformate
232	benzyl chloroformate
233	isopropyl chloroformate
234	methyl chloroformate
235	ethyl chloroformate
10 236	butyl chloroformate
237	3- butenyl chloroformate

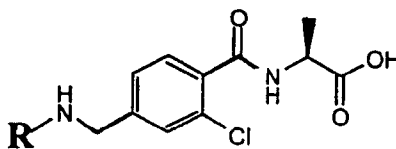
## Examples 238-240



Examples 238-240 were synthesized by Method S37.

Example #	R group
15 238	3- hydroxy benzoic acid
239	2- hydroxy cinnamic acid
240	3- hydroxy benzoic acid

## Examples 241-245

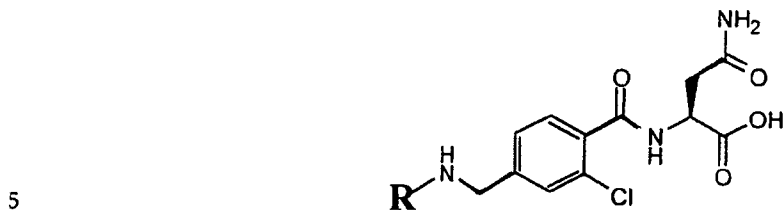


Examples 241-245 were synthesized by Method S38.

Example #	R group
241	3- hydroxy benzoic acid
242	2- hydroxy cinnamic acid

- 243 3- chloro benzoic acid  
 244 indole 5- carboxylic acid  
 245 3- (2- thienyl)acrylic acid

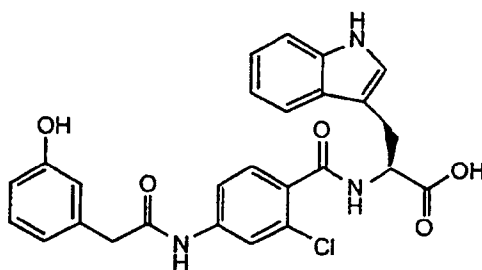
## Examples 246-253



Examples 246-253 were synthesized by Method S39.

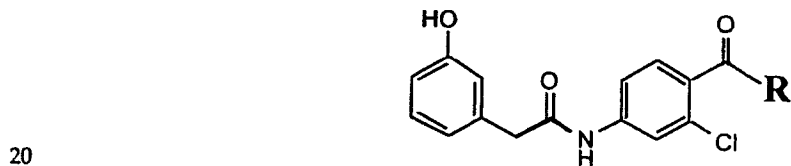
Example #	R group
246	3- chlorobenzoic acid
247	3 - (2 - thienyl)acrylic acid
10 248	2 - furanacrylic acid
249	3- hydroxy benzoic acid
250	indole 5-carboxylic acid
251	benzofuran 5-carboxylic acid
252	benzofuran 4-carboxylic acid
15 253	indole 6-carboxylic acid

## Examples 254



Examples 254 were synthesized by Method S40.

## Examples 255-256

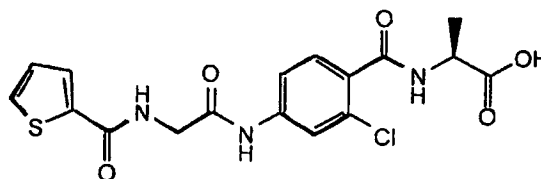


Examples 255-256 were synthesized by Method S41.

Example #	R group
255	L - Ala
256	L - Thr

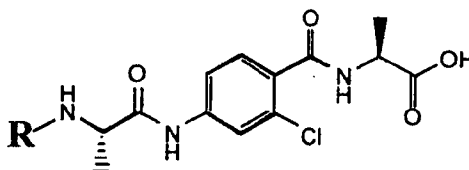


Example 257



Example 257 was synthesized by Method S42.

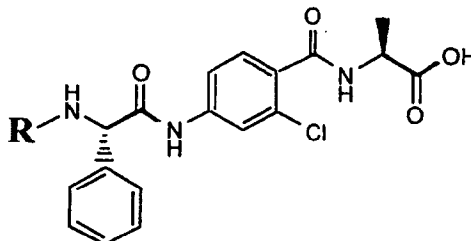
Examples 258-259



Examples 258-259 were synthesized by Method S43.

Example #	R group
258	2-thiophene carboxylic acid
259	3-hydroxybenzoic acid

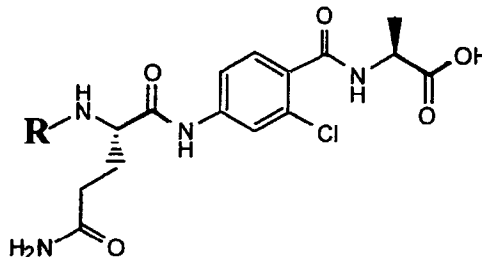
Examples 260-261



Examples 260-261 were synthesized by Method S44.

Example #	R group
260	3-hydroxybenzoic acid
261	2-thiophene carboxylic acid

Examples 262-263



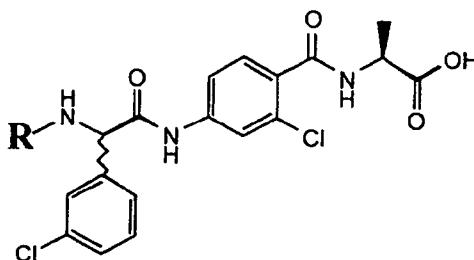
Examples 262-263 were synthesized by Method S45.

Example #	R group
262	benzoic acid

263

2-thiophene carboxylic acid

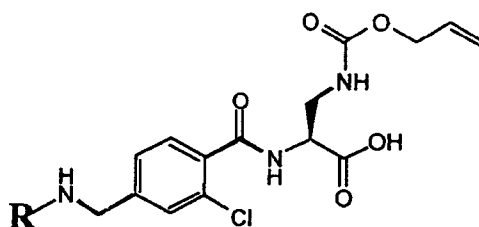
Examples 264-265



Examples 264-265 were synthesized by Method S46.

5	Example #	R group
	264	3-hydroxybenzoic acid
	265	2-thiophene carboxylic acid

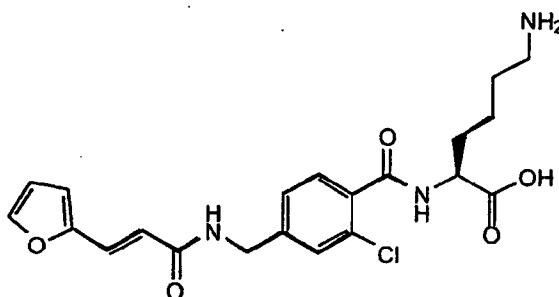
Examples 266-267



10 Examples 266-267 were synthesized by Method S47.

	Example #	R group
	266	3-(2-thienyl)-acrylic acid
	267	furylacrylic acid

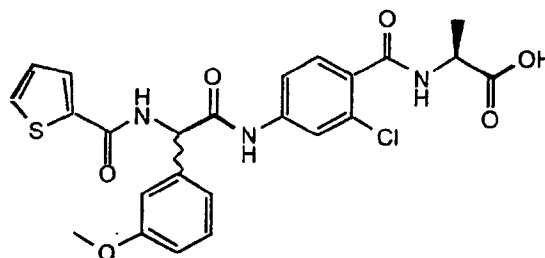
Example 268



15

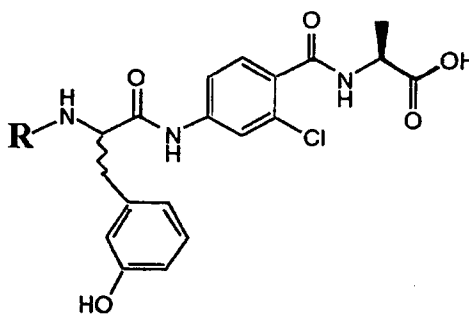
Example 268 was synthesized by Method S48.

Example 269



Example 269 was synthesized by Method S49.

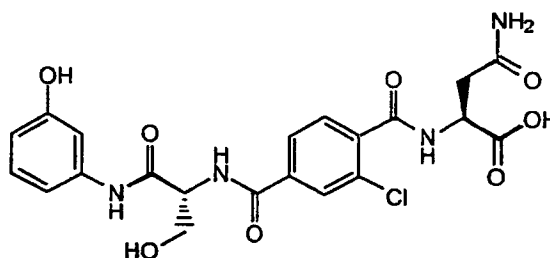
Examples 270-271



Examples 270-271 were synthesized by Method S50.

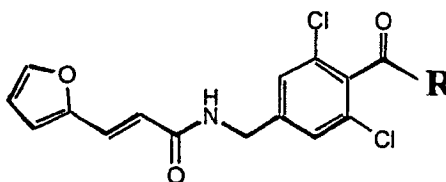
Example #	R group
270	3- hydroxybenzoic acid
271	2- thiophene carboxylic acid

Example 272



Example 272 was synthesized by Method S51.

Examples 273-275

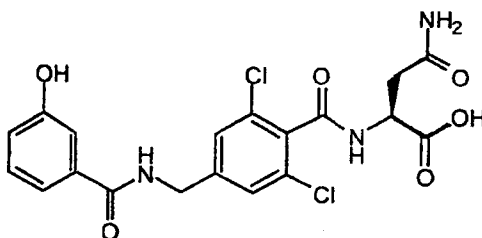


Examples 273-275 were synthesized by Method S52.

Example #	R group
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273	L- Ala
274	L- Asn
275	L- diaminopropionic acid (alloc)

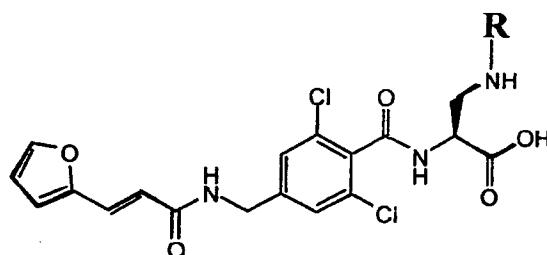
## Example 276



5

Example 276 was synthesized by Method S53.

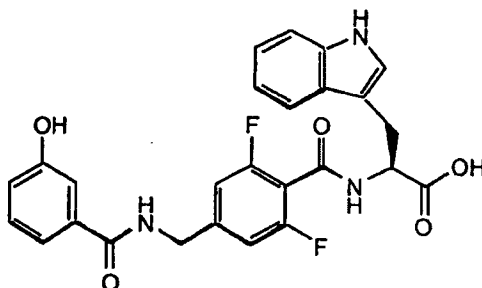
## Examples 277-282



Examples 277-282 were synthesized by Method S54.

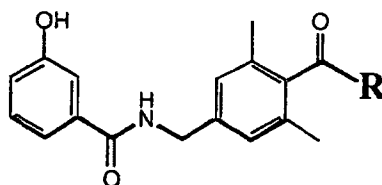
10	Example #	R group
	277	thiophene 2- carboxylic acid
	278	2- furoic acid
	279	2- pyrazinecarboxylic acid
	280	3- methyl thiophene 2- carboxylic acid
15	281	3- methyl 2- furoic acid
	282	3- chloro thiophene 2- carboxylic acid

## Example 283



Example 283 was synthesized by Method S55.

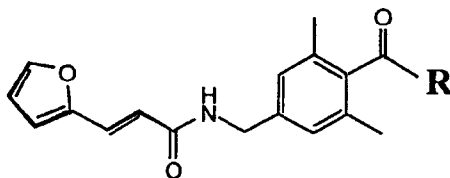
## Examples 284-285



Examples 284-285 were synthesized by Method S56.

Example #	R group
5 284	L- Ala
285	L- Asn

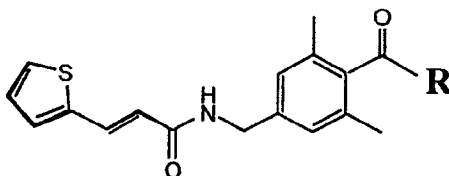
## Examples 286-287



Examples 286-287 were synthesized by Method S57.

Example #	R group
10 286	L- diaminopropionic acid (alloc)
287	L- Lys

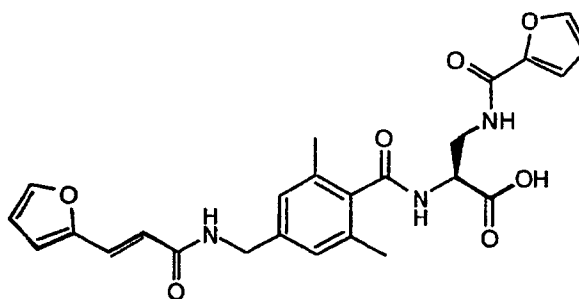
## Examples 288-289



15 Examples 288-289 were synthesized by Method S58.

Example #	R group
288	L- diaminopropionic acid (alloc)
289	L- Lys

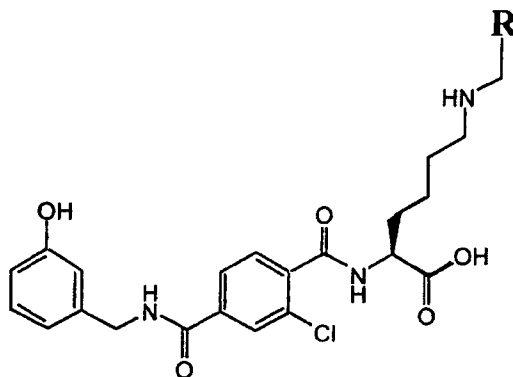
## Example 290



20

Example 290 was synthesized by Method S59.

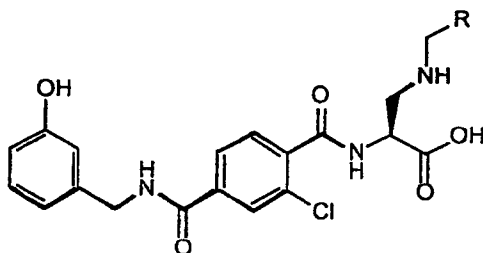
#### Examples 291-292



Examples 291-292 were synthesized by Method S60.

5	Example #	R group
	291	2- furaldehyde
	292	3- methyl 2- furaldehyde

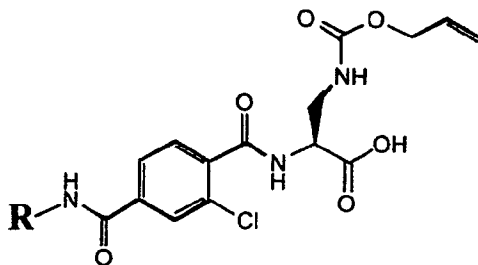
#### Examples 293-294



10 Examples 293-294 were synthesized by Method S61.

	Example #	R group
	293	2- furaldehyde
	294	3- methyl 2- furaldehyde

#### Examples 295-296



15

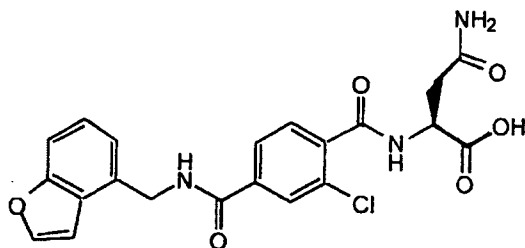
Examples 295-296 were synthesized by Method S62.

	Example #	R group
	295	6- aminomethyl benzofuran

296

4- aminomethyl benzofuran

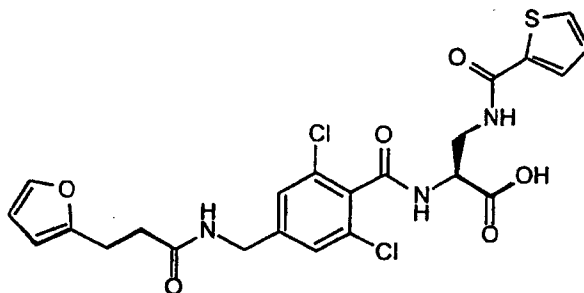
Example 297



Example 297 was synthesized by Method S63.

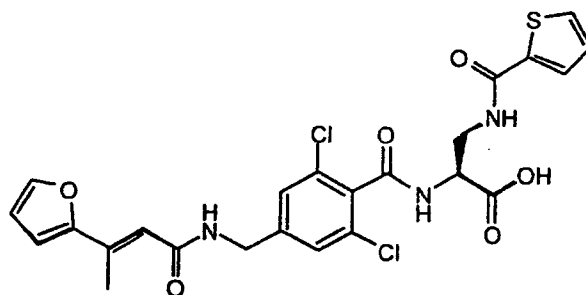
5

Example 298



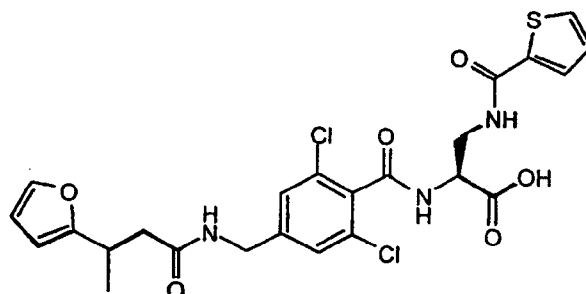
Example 298 was synthesized by Method S64.

Example 299



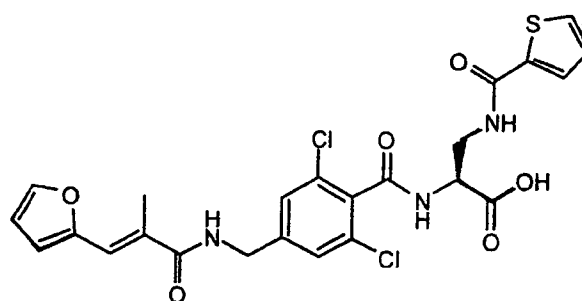
10 Example 299 was synthesized by Method S65.

Example 300



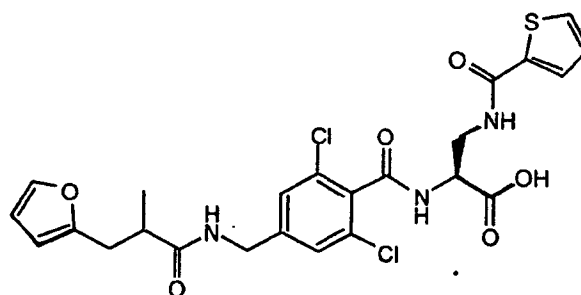
Example 300 was synthesized by Method S66.

## Example 301



Example 301 was synthesized by Method S67.

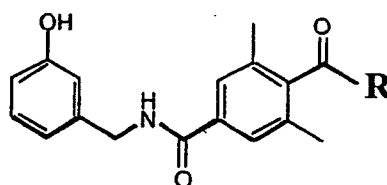
## Example 302



5

Example 302 was synthesized by Method S68.

## Examples 303-305

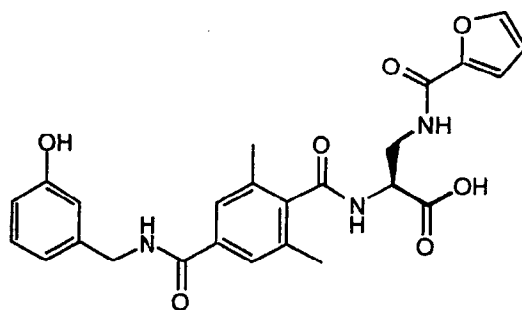


Examples 303-305 were synthesized by Method S69.

10	Example #	R group
	303	L- Asn
	304	L- diaminopropionic acid (alloc)
	305	L- lys

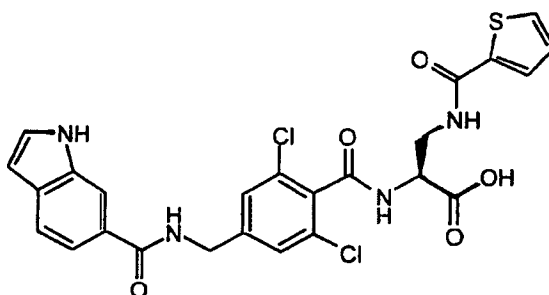


## Example 306



Example 306 was synthesized by Method S70.

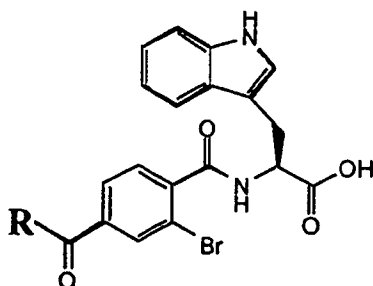
## Example 307



5

Example 307 was synthesized by Method S71.

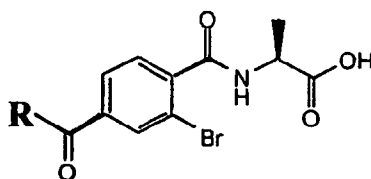
## Examples 308-309



Examples 308-309 were synthesized by Method S72.

10	Example #	R group
	308	3-hydroxy benzylamine
	309	3-(3-hydroxyphenyl)propargylamine

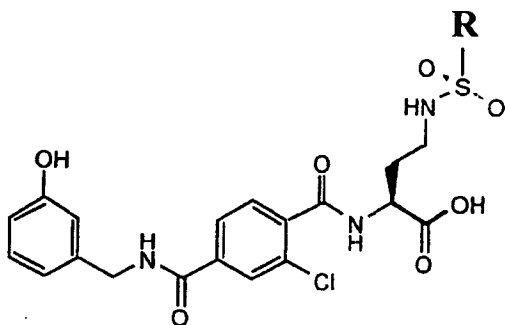
## Examples 310-312



15 Examples 310-312 were synthesized by Method S73.

Example #	R group
310	3-fluorobenzylamine
311	benzylamine
312	3-(3-hydroxyphenyl)propargylamine

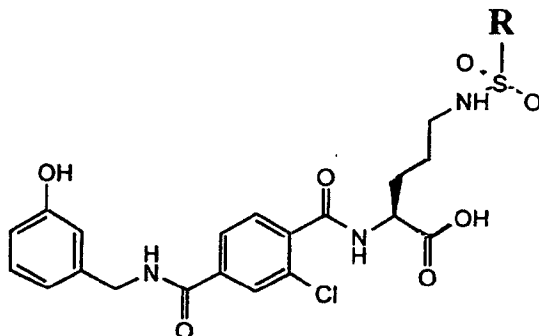
Examples 313-315



Examples 313-315 were synthesized by Method S74.

Example #	R group
313	N-acetylsulfanilyl chloride
314	2-bromobenzenesulfonyl chloride
315	2-thiophenesulfonyl chloride

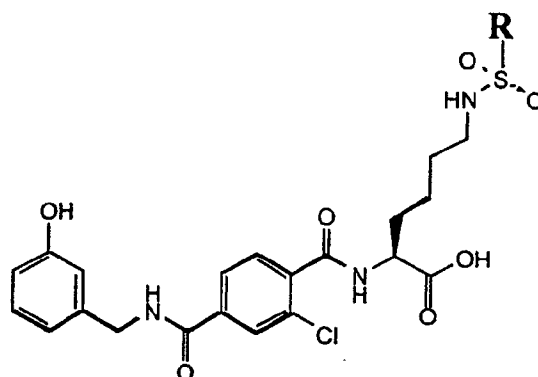
Examples 316-317



Examples 316-317 were synthesized by Method S75.

Example #	R group
316	2-thiophenesulfonyl chloride
317	8-quinolinesulfonyl chloride

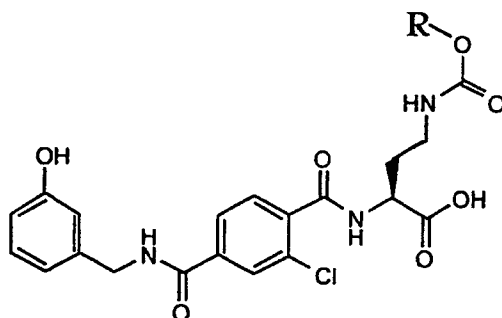
## Examples 318-322



Examples 318-322 were synthesized by Method S76.

Example #	R group
318	benzenesulfonyl chloride
319	N-acetylsulfanilyl chloride
320	2-thiophenesulfonyl chloride
321	2-bromobenzenesulfonyl chloride
322	2-acetamido-4-methyl-5-thiazolesulfonyl chloride

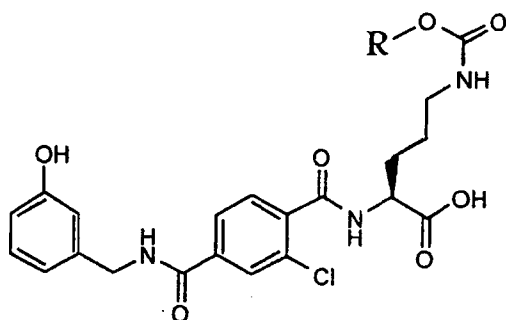
## Examples 323-328



Examples 323-328 were synthesized by Method S77.

Example #	R group
323	isobutyl chloroformate
324	allyl chloroformate
325	butyl chloroformate
326	ethyl chloroformate
327	isopropyl chloroformate
328	propyl chloroformate

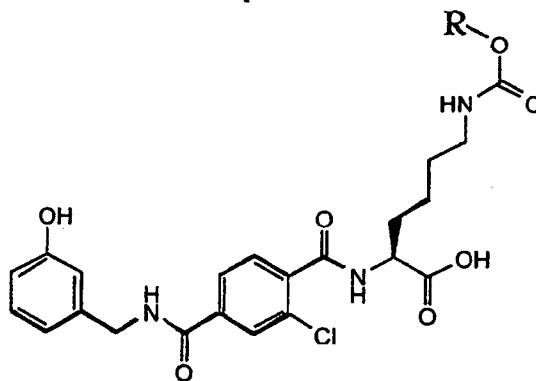
## Examples 329-333



Examples 329-333 were synthesized by Method S78.

Example #	R group
329	isobutyl chloroformate
330	cyclopropyl chloroformate
331	ethyl chloroformate
332	methyl chloroformate
333	2, 2, 2-trichloroethyl chloroformate

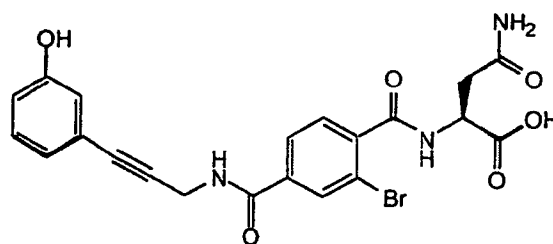
## Examples 334-337



Examples 334-337 were synthesized by Method S79.

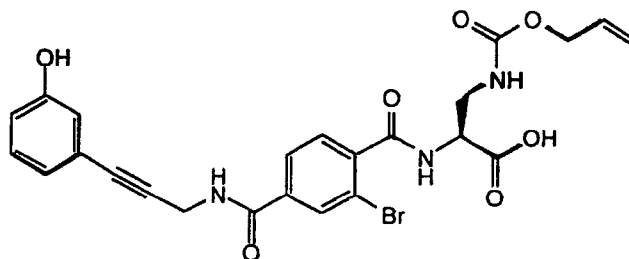
Example #	R group
334	butyl chloroformate
335	propyl chloroformate
336	ethyl chloroformate
337	methyl chloroformate

Example 338



Example 338 was synthesized by Method S80.

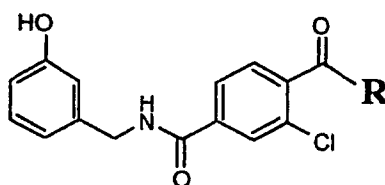
Example 339



5

Example 339 was synthesized by Method S81.

Examples 340-354



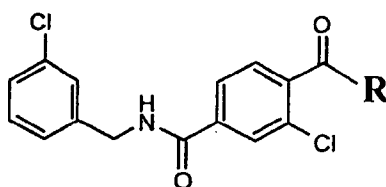
Examples 340-354 were synthesized by Method S82.

10	Example #	R group
	340	L - Ala
	341	L - Thr
	342	L - Trp
	343	L - aza Trp
15	344	L - Ser(OBzl)
	345	L - Asn
	346	L - Lys
	347	L - His
	348	L - Lys(N- e- Ac)
20	349	L - Gln
	350	L-diaminopropionic(alloc) acid
	351	L-diaminobutyric(alloc) acid
	352	L-lys(alloc)
	353	L-orn(alloc)

354

L- Tyr

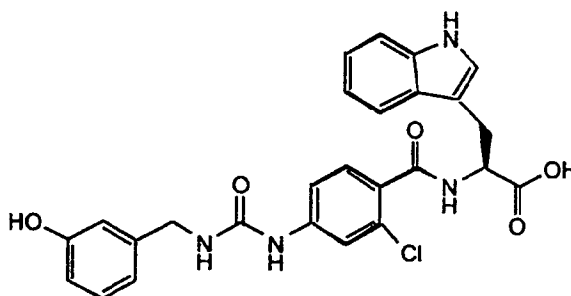
Examples 355-357



Examples 355-357 were synthesized by Method S83.

5	Example #	R group
	355	L - Ala
	356	L - His
	357	L - Asn

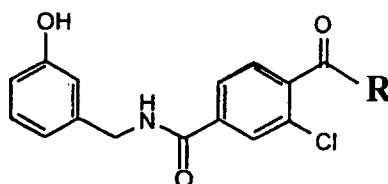
Example 358



10

Example 358 was synthesized by Method S84.

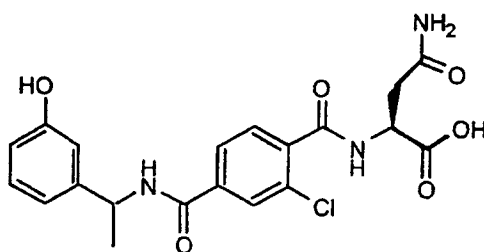
Examples 359-362



Examples 359-362 were synthesized by Method S85.

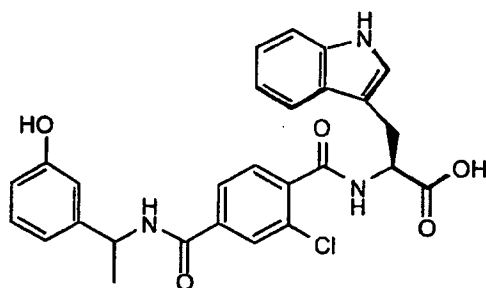
15	Example #	R group
	359	1-amino-1-cyclopropane carboxylic acid
	360	m-tyrosine
	361	o-hydroxytyrosine
	362	L-iodotyrosine

Example 363



Example 363 was synthesized by Method S86.

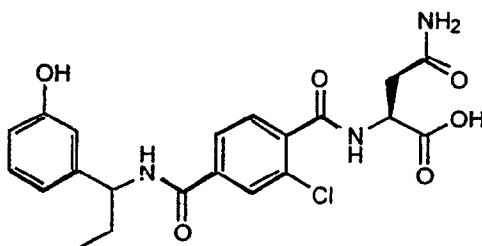
Example 364



5

Example 364 was synthesized by Method S87.

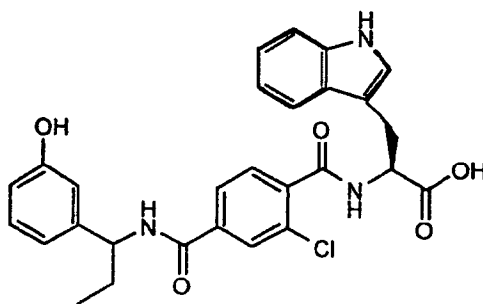
Example 365



Example 365 was synthesized by Method S88.

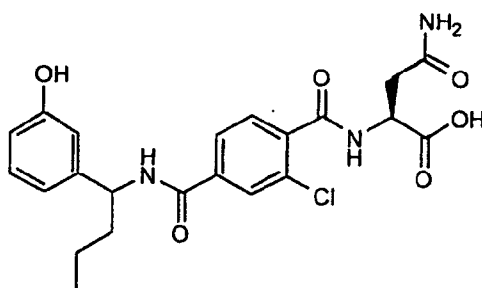
10

Example 366



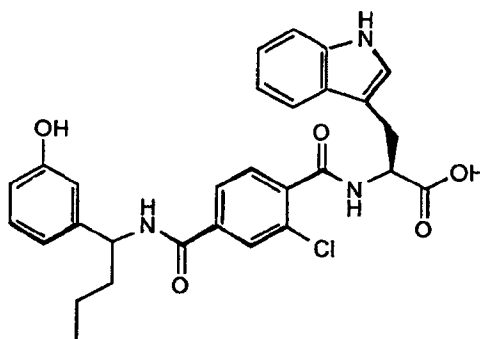
Example 366 was synthesized by Method S89.

Example 367



Example 367 was synthesized by Method S90.

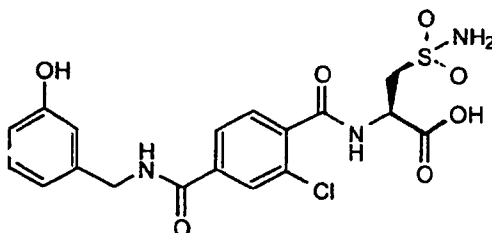
Example 368



5

Example 368 was synthesized by Method S91.

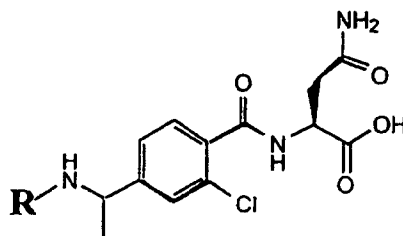
Example 369



Example 369 was synthesized by Method S92.

10

Examples 370-371



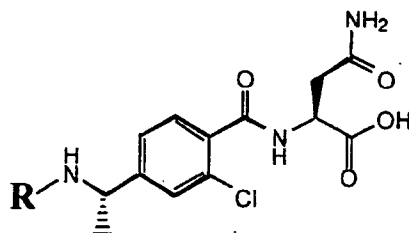
Examples 370-371 were synthesized by Method S93.

Example #	R group
370	3 - hydroxybenzoic acid



371 benzoic acid

## Examples 372-375

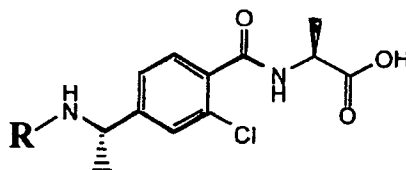


Examples 372-375 were synthesized by Method S94.

5	Example #	R group
	372	furylacrylic acid
	373	3-(2-thienyl)-acrylic acid
	374	3 - hydroxybenzoic acid
	375	benzoic acid

10

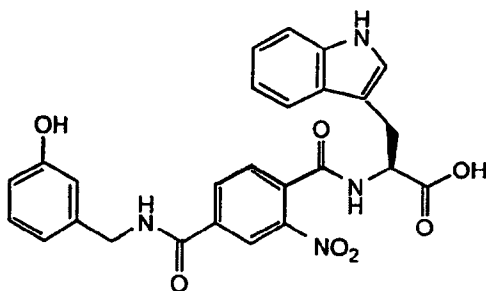
## Examples 376-377



Examples 376-377 were synthesized by Method S95.

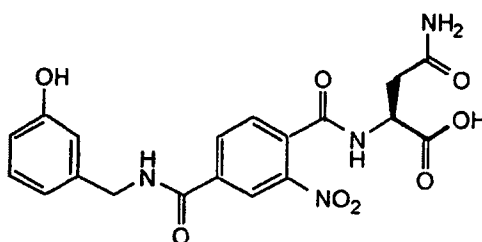
	Example #	R group
	376	3 - hydroxybenzoic acid
15	377	3-(2-thienyl)-acrylic acid

## Example 378



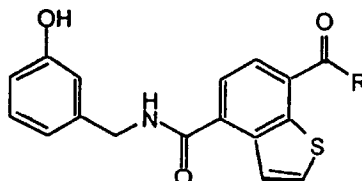
Example 378 was synthesized by Method S96.

## Example 379



Example 379 was synthesized by Method S97.

## Examples 380-383

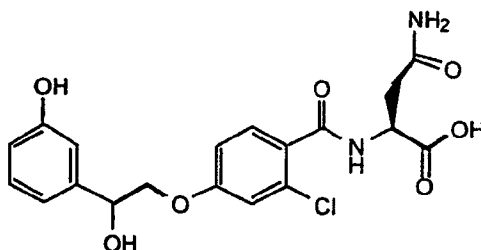


5

Examples 380-383 were synthesized by Method S98.

Example #	R group
380	L- Trp
381	L- Asn
10 382	L- dapa(alloc)
383	L- Lys

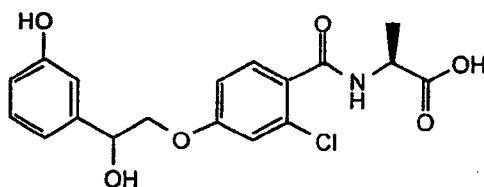
## Example 384



Example 383 was synthesized by Method S99.

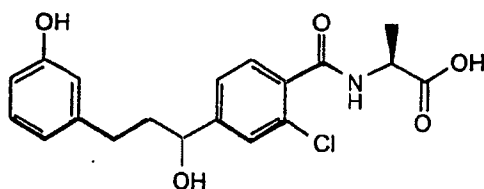
15

## Example 385



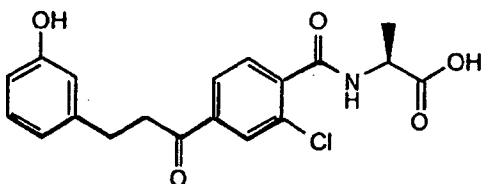
Example 385 was synthesized by Method S100.

Example 386



Example 386 was synthesized by Method S101.

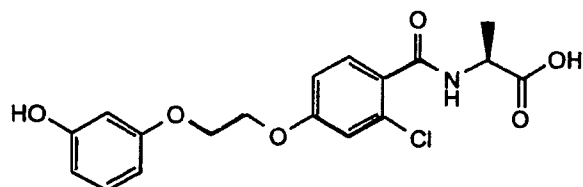
Example 387



5

Example 387 was synthesized by Method S102.

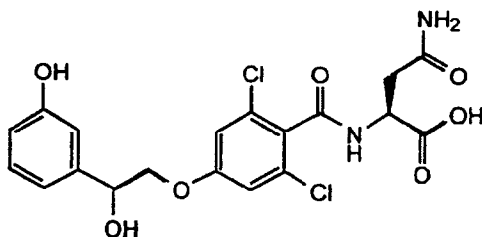
Example 388



Example 388 was synthesized by Method S103.

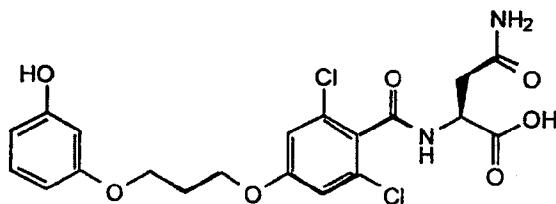
10

Example 389



Example 389 was synthesized by Method S104.

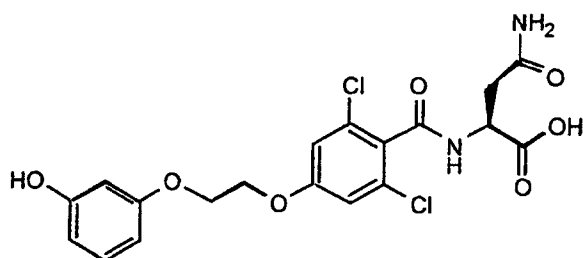
Example 390



15

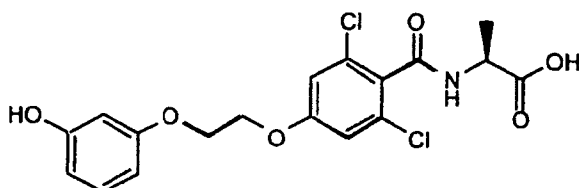
Example 390 was synthesized by Method S105.

Example 391



Example 391 was synthesized by Method S106.

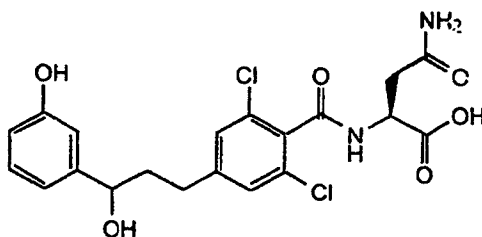
Example 392



5

Example 392 was synthesized by Method S107.

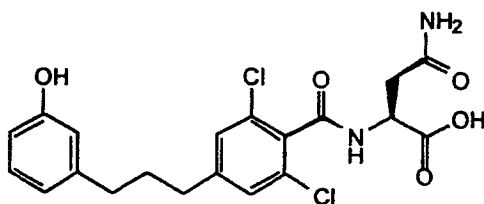
Example 393



Example 393 was synthesized by Method S108.

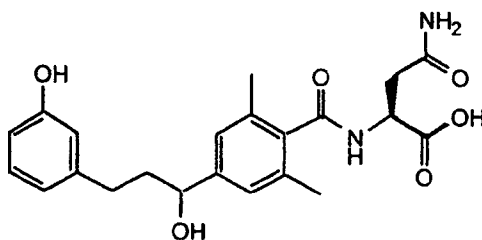
10

Example 394



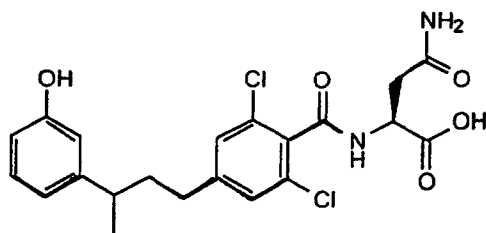
Example 394 was synthesized by Method S109.

Example 395



Example 395 was synthesized by Method S110.

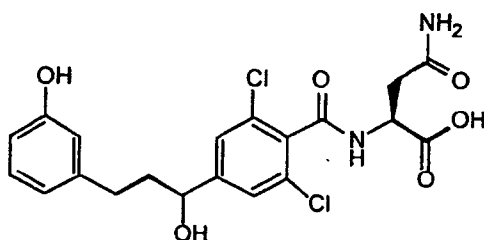
Example 396



Example 396 was synthesized by Method S111.

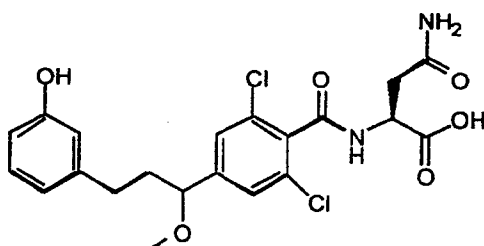
5

Example 397



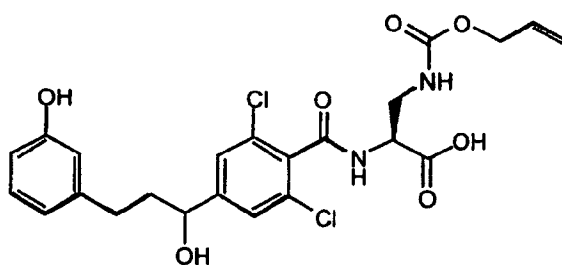
Example 397 was synthesized by Method S112.

Example 398



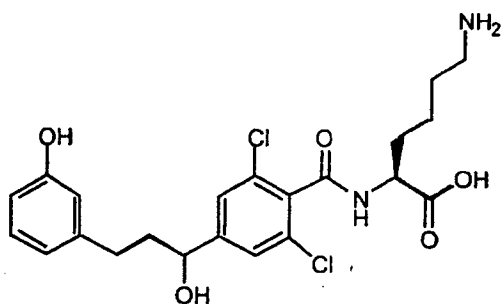
10 Example 398 was synthesized by Method S113.

Example 399



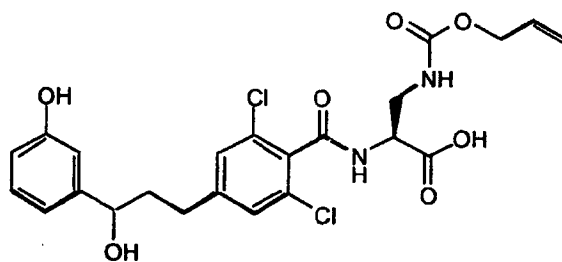
Example 399 was synthesized by Method S114.

Example 400



Example 400 was synthesized by Method S115.

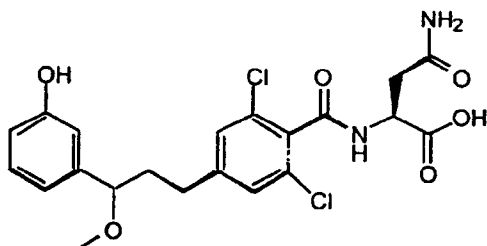
Example 401



5

Example 401 was synthesized by Method S116.

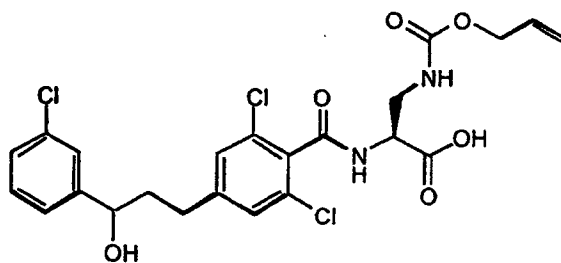
Example 402



Example 402 was synthesized by Method S117.

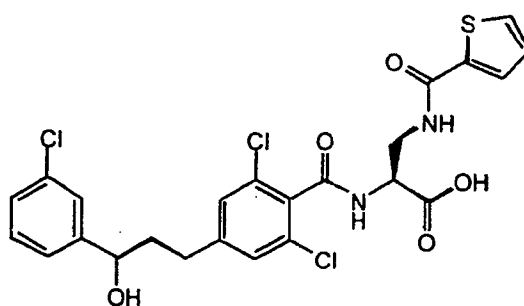
10

Example 403



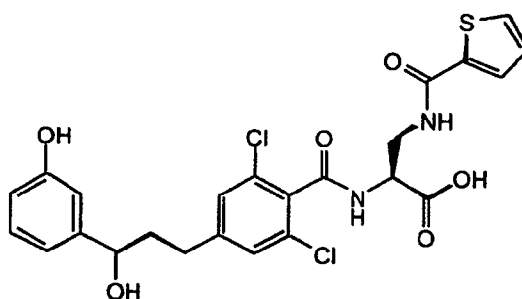
Example 403 was synthesized by Method S118.

Example 404



Example 404 was synthesized by Method S119.

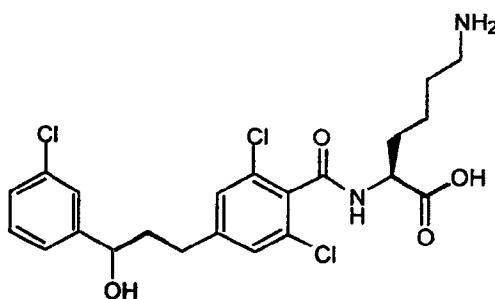
Example 405



5

Example 405 was synthesized by Method S120.

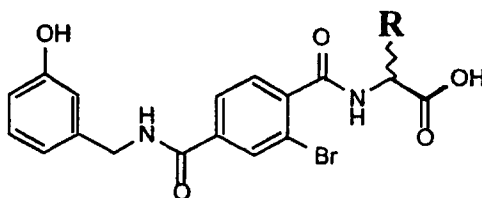
Example 406



Example 406 was synthesized by Method S121.

10

Examples 407-416



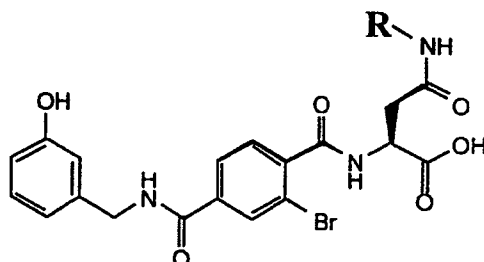
Examples 407-416 were synthesized by Method S122.

Example #	R group
407	3-methoxybenzyl bromide

408	3-bromobenzyl bromide
409	3, 5-dimethoxybenzyl bromide
410	5-bromovaleronitrile
411	6-bromohexanenitrile
5 412	3-nitrobenzyl bromide
413	3-cyanobenzyl bromide
414	5-bromomethyl-furan-2-carboxylic acid ethyl ester
415	5-bromomethyl-furan-2-carboxylic acid ethyl ester
416	3-bromomethyl benzamide

10

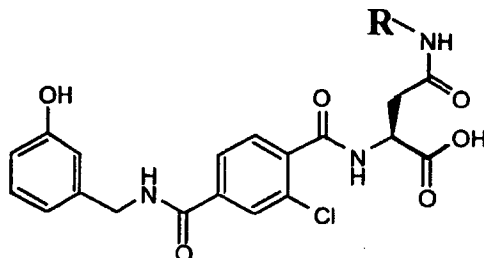
Examples 417-423



Examples 417-413 were synthesized by Method S123.

Example #	R group
417	1-aminonaphthalene
15 418	2-cyanoaniline
419	3-cyanoaniline
420	2-fluoroaniline
421	3-fluoroaniline
422	4-fluoroaniline
20 423	3-methoxyaniline

Examples 424-436



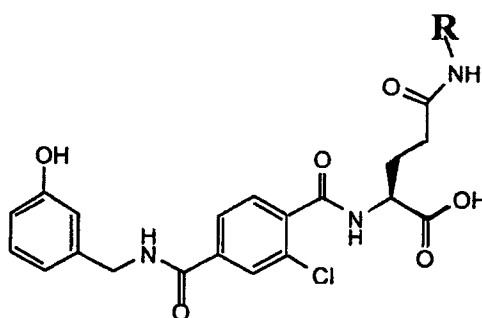
Examples 424-436 were synthesized by Method S124.

Example #	R group
25 424	2-(aminomethyl)pyridine
425	3-fluorobenzylamine



	426	benzylamine
	427	allylamine
	428	phenethyl amine
	429	histamine
5	430	4-fluorobenzylamine
	431	3-methoxyphenethylamine
	432	4-aminobenzylamine
	433	2-aminobenzylamine
	434	2-[1, 3]Dioxan-5-yl-ethylamine
10	435	piperonylamine
	436	aniline

## Examples 437-440

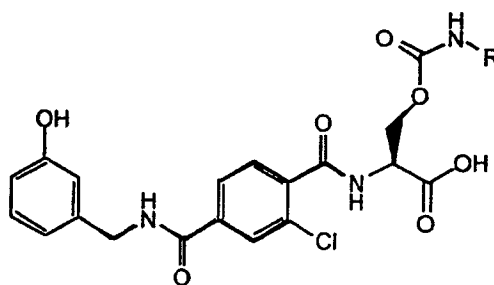


Examples 437-440 were synthesized by Method S125.

15	Example #	R group
	437	isoamyl amine
	438	4-(aminomethyl)pyridine
	439	2-[1, 3]Dioxan-5-yl-ethylamine
	440	aniline

20

## Examples 441-443



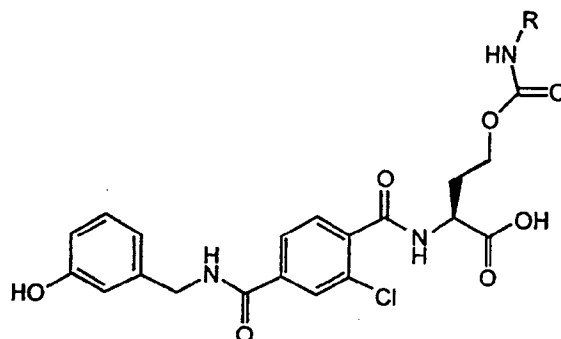
Examples 441-443 were synthesized by Method S126.

	Example #	R group
	441	o- toluidine
25	442	allyl amine

443

propyl amine

### Examples 444-459



Examples 444-459 were synthesized by Method S127.

5	Example #	R group
	444	propylamine
	445	3-(aminomethyl)pyridine
	446	4-(aminomethyl)pyridine
	447	2- methylbenzylamine
10	448	3- methylbenzylamine
	449	4- methylbenzylamine
	450	(S)-(-)-a-methylbenzylamine
	451	2-(aminomethyl)pyridine
	452	2- fluoro benzylamine
15	453	3- fluoro benzylamine
	454	4- fluoro benzylamine
	455	3- chloro benzylamine
	456	4- chloro benzylamine
	457	4- methoxy benzylamine
20	458	1- naphthalenemethylamine
	459	benzylamine

Table 3 provides biological assay data for the compounds prepared by the methods described above. Data is provided for two assay formats: the forward format of LFA/ICAM assay (PPFF) and the PLM2 antibody capture format of LFA/ICAM assay (PLM2).

### Table 3

### PPFF and PLM2 assay data for exemplary compounds

Example #	PPFF( $\mu$ M)	PLM2( $\mu$ M)
1	0.149	0.028
2		0.035
30 3		0.069

	4	0.038
	5	0.013
	6	0.045
	7	0.004
5	8	0.021
	9	0.033
	10	0.003
	11	0.065
	12	0.029
10	13	0.064
	14	0.024
	15	0.010
	16	0.011
	17	0.036
15	18	0.010
	19	0.037
	20	0.029
	21	0.023
	22	0.019
20	23	0.072
	24	0.012
	25	0.019
	26	0.021
	27	0.008
25	28	0.092
	29	0.055
	30	0.064
	31	0.014
	32	0.047
30	33	0.023
	34	0.078
	35	0.069
	36	0.013
	37	0.038
35	38	0.013
	39	0.021
	40	0.076
	41	0.098

	42	0.046
	43	0.098
	44	0.095
	45	0.059
5	46	0.066
	47	0.070
	48	0.046
	49	0.038
	50	0.052
10	51	0.056
	52	0.050
	53	0.094
	54	0.014
	55	0.047
15	56	0.052
	57	0.036
	58	0.080
	59	0.066
	60	0.078
20	61	0.052
	62	0.046
	63	0.062
	64	0.055
	65	0.044
25	66	0.072
	67	0.046
	68	0.071
	69	0.084
	70	0.088
30	71	0.040
	72	0.063
	73	0.063
	74	0.087
	75	0.011
35	76	0.010
	77	0.017
	78	0.031
	79	0.033

	80	0.005
	81	0.008
	82	0.004
	83	0.006
5	84	0.001
	85	0.003
	86	0.012
	87	0.009
	88	0.005
10	89	0.004
	90	0.021
	91	0.004
	92	0.066
	93	0.024
15	94	0.002
	95	0.006
	96	0.070
	97	0.042
	98	0.033
20	99	0.046
	100	0.031
	101	0.022
	102	0.025
	103	0.044
25	104	0.044
	105	0.004
	106	0.026
	107	0.087
	108	0.021
30	109	0.026
	110	0.052
	111	0.007
	112	0.036
	113	0.086
35	114	0.018
	115	0.073
	116	0.026
	117	0.045

	118	0.031
	119	0.077
	120	0.064
	121	0.055
5	122	0.050
	123	0.054
	124	0.035
	125	0.058
	126	0.033
10	127	0.017
	128	0.035
	129	0.029
	130	0.036
	131	0.025
15	132	0.057
	133	0.020
	134	0.053
	135	0.021
	136	0.029
20	137	0.039
	138	0.071
	139	0.064
	140	0.023
	141	0.068
25	142	0.074
	143	0.031
	144	0.093
	145	0.004
	146	0.004
30	147	0.004
	148	0.004
	149	0.004
	150	0.004
	151	0.004
35	152	0.004
	153	0.003
	154	0.003
	155	0.006

	156	0.009
	157	0.007
	158	0.004
	159	0.017
5	160	0.004
	161	0.004
	162	0.004
	163	0.005
	164	0.012
10	165	0.015
	166	0.018
	167	0.017
	168	0.012
	169	0.006
15	170	0.007
	171	0.011
	172	0.037
	173	0.010
	174	0.004
20	175	0.005
	176	0.011
	177	0.006
	178	0.011
	179	0.009
25	180	0.011
	181	0.016
	182	0.011
	183	0.013
	184	0.016
30	185	0.016
	186	0.015
	187	0.017
	188	0.018
	189	0.018
35	190	0.016
	191	0.016
	192	0.029
	193	0.014

	194	0.012
	195	0.016
	196	0.019
	197	0.017
5	198	0.019
	199	0.029
	200	0.018
	201	0.013
	202	0.023
10	203	0.037
	204	0.025
	205	0.082
	206	0.023
	207	0.062
15	208	0.021
	209	0.053
	210	0.022
	211	0.019
	212	0.016
20	213	0.035
	214	0.028
	215	0.027
	216	0.022
	217	0.031
25	218	0.018
	219	0.018
	220	0.016
	221	0.042
	222	0.021
30	223	0.035
	224	0.026
	225	0.029
	226	0.025
	227	0.034
35	228	0.018
	229	0.026
	230	0.016
	231	0.003



	232		0.005
	233		0.001
	234		0.044
	235		0.002
5	236		0.004
	237		0.003
	238	0.099	
	239	0.180	0.053
	240	0.085	
10	241	0.053	
	242	0.054	
	243	0.082	
	244	0.077	0.078
	245	0.058	0.164
15	246	0.067	0.059
	247	0.022	0.034
	248	0.027	0.026
	249	0.030	
	250		0.034
20	251		0.038
	252		0.060
	253		0.014
	254	0.094	0.036
	255	0.042	
25	256	0.076	
	257		0.042
	258		0.038
	259		0.049
	260		0.071
30	261		0.052
	262		0.075
	263		0.066
	264		0.093
	265		0.045
35	266		0.046
	267		0.021
	268		0.019
	269		0.046

	270		0.055
	271		0.086
	272		0.080
	273		0.016
5	274		0.006
	275		0.006
	276		0.012
	277		0.003
	278		0.002
10	279		0.004
	280		0.007
	281		0.004
	282		0.024
	283	0.092	
15	284	0.093	0.079
	285	0.064	
	286		0.014
	287		0.043
	288		0.023
20	289		0.074
	290		0.009
	291		0.007
	292		0.015
	293		0.083
25	294		0.100
	295		0.047
	296		0.017
	297		0.028
	298		0.009
30	299		0.016
	300		0.074
	301		0.025
	302		0.023
	303		0.005
35	304		0.003
	305		0.015
	306		0.004
	307		0.004

	308	0.061	
	309		0.057
	310	0.082	
	311	0.079	
5	312		0.089
	313		0.069
	314		0.028
	315		0.037
	316		0.030
10	317		0.055
	318		0.031
	319		0.023
	320		0.007
	321		0.020
15	322		0.011
	323		0.036
	324		0.042
	325		0.056
	326		0.042
20	327		0.070
	328		0.074
	329		0.033
	330		0.009
	331		0.027
25	332		0.057
	333		0.090
	334		0.072
	335		0.096
	336		0.066
30	337		0.079
	338		0.060
	339		0.020
	340	0.014	0.006
	341	0.031	
35	342	0.057	0.004
	343	0.030	
	344	0.183	0.053
	345	0.019	0.004

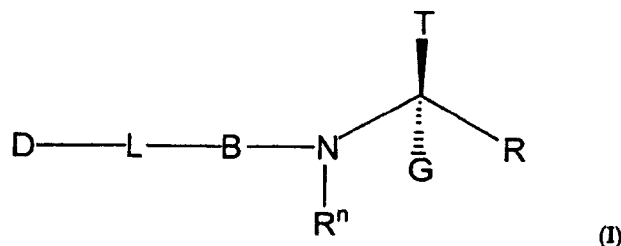
	346	0.071	
	347	0.044	0.004
	348	0.090	0.023
	349	0.042	
5	350	0.027	0.005
	351	0.067	0.032
	352		0.042
	353		0.074
	354		0.008
10	355	0.100	0.094
	356	0.068	
	357	0.057	0.023
	358	0.230	0.032
	359		0.016
15	360		0.018
	361		0.018
	362		0.005
	363	0.014	0.010
	364	0.087	0.035
20	365		0.024
	366		0.062
	367		0.020
	368		0.043
	369		0.019
25	370	0.055	0.025
	371	0.055	0.037
	372		0.013
	373		0.021
	374		0.021
30	375		0.040
	376	0.078	0.061
	377	0.016	0.051
	378		0.007
	379		0.010
35	380		0.096
	381		0.035
	382		0.012
	383		0.060

	384	0.046	0.018
	385	0.070	0.048
	386	0.030	
	387	0.098	0.043
5	388	0.050	
	389	0.054	0.010
	390		0.079
	391		0.007
	392		0.025
10	393		0.003
	394		0.012
	395		0.006
	396		0.062
	397		0.005
15	398		0.015
	399		0.002
	400		0.007
	401		0.002
	402		0.004
20	403		0.009
	404		0.002
	405		0.001
	406		0.022
	407		0.045
25	408		0.071
	409		0.054
	410		0.065
	411		0.055
	412		0.074
30	413	0.051	0.045
	414		0.087
	415		0.059
	416		0.036
	417		0.086
35	418		0.056
	419		0.079
	420		0.015
	421		0.056

	422		0.083
	423		0.032
	424		0.038
	425		0.082
5	426		0.057
	427		0.044
	428		0.029
	429		0.094
	430		0.070
10	431		0.070
	432		0.070
	433		0.046
	434		0.050
	435		0.074
15	436		0.011
	437	0.083	0.034
	438		0.082
	439		0.089
	440		0.068
20	441		0.015
	442		0.006
	443		0.010
	444		0.041
	445		0.029
25	446		0.020
	447		0.085
	448		0.094
	449		0.071
	450		0.061
30	451		0.030
	452		0.040
	453		0.056
	454		0.046
	455		0.071
35	456		0.064
	457		0.036
	458		0.083
	459		0.058

## WHAT IS CLAIMED IS:

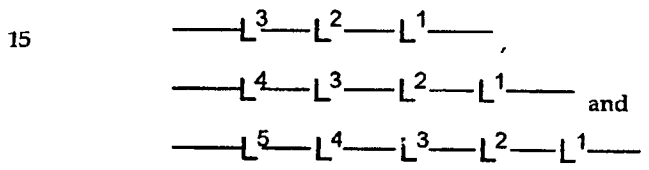
- 1) A method of treating or ameliorating an immune or inflammatory response or disorder in a mammal mediated through the CD11/CD18 family of cellular adhesion molecules comprising administering to the mammal a therapeutically effective amount of a compound represented by structural formula (I)



where

- D is a mono-, bi-, or tricyclic saturated, unsaturated, or aromatic ring, each ring having 5-, 6- or 7 atoms in the ring where the atoms in the ring are carbon or from one to four heteroatoms selected from the group nitrogen, oxygen, and sulfur, where any carbon or sulfur ring atom may optionally be oxidized, each ring substituted with 0-3 R<sup>d</sup>;

L is a bivalent linking group selected from the group



where

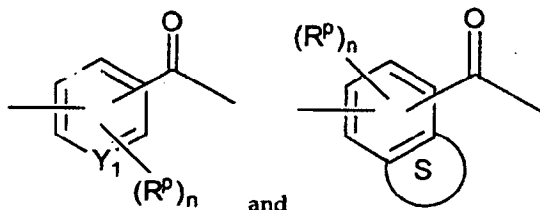
- L<sup>1</sup> is selected from oxo (-O-), S(O)<sub>s</sub>, C(=O), CR<sup>1</sup>R<sup>1'</sup>, CR<sup>1</sup>, het, NR<sup>n</sup> and N,
- L<sup>2</sup> is selected from oxo (-O-), S(O)<sub>s</sub>, C(=O), C(=N-O-R<sup>0</sup>), CR<sup>2</sup>R<sup>2'</sup>, CR<sup>2</sup>, het, NR<sup>n</sup> and N,
- L<sup>3</sup> is selected from oxo (-O-), S(O)<sub>s</sub>, C(=O), C(=N-O-R<sup>0</sup>), CR<sup>3</sup>R<sup>3'</sup>, CR<sup>3</sup>, het, NR<sup>n</sup> and N,
- L<sup>4</sup> is absent or is selected from oxo (-O-), S(O)<sub>s</sub>, C(=O), C(=N-O-R<sup>0</sup>), CR<sup>4</sup>R<sup>4'</sup>, CR<sup>4</sup>, NR<sup>n</sup> and N, and
- L<sup>5</sup> is absent or is selected from oxo (-O-), S(O)<sub>s</sub>, C(=O), CR<sup>5</sup>R<sup>5'</sup>, CR<sup>5</sup>, NR<sup>n</sup> and N, provided that only one of L<sup>1</sup> - L<sup>3</sup> may be het and that when one of L<sup>1</sup> - L<sup>3</sup> is het the other L<sup>1</sup> - L<sup>5</sup> may be absent,
- where
- R<sup>1</sup>, R<sup>1'</sup>, R<sup>2</sup>, R<sup>2'</sup>, R<sup>3</sup>, R<sup>3'</sup>, R<sup>4</sup>, R<sup>4'</sup>, R<sup>5</sup> and R<sup>5'</sup> each are independently selected from R<sup>a</sup>, R<sup>c</sup> and U-Q-V-W,

optionally,  $R^2$  and  $R^{2'}$  separately or together may form a saturated, unsaturated or aromatic fused ring with B through a substituent  $R^P$  on B, the fused ring containing 5, 6 or 7 atoms in the ring and optionally containing 1-3 heteroatoms selected from the group O, S and N, where any S or N may optionally be oxidized;

- 5 optionally,  $R^3$  and  $R^{3'}$  separately or together and  $R^4$  and  $R^{4'}$  separately or together may form a saturated, unsaturated or aromatic fused ring with D through a substituent  $R^d$  on D, the fused ring containing 5, 6 or 7 atoms in the ring and optionally containing 1-3 heteroatoms selected from the group O, S and N, where any S or N may optionally be oxidized;

also optionally, each  $R^1-R^{5'}$ ,  $NR^n$  or N in  $L^1-L^5$  together with any other  $R^1-R^{5'}$ ,  $NR^n$  or N in  $L^1-$

- 10  $L^5$  may form a 5, 6 or 7 member homo- or heterocycle either saturated, unsaturated or aromatic optionally containing 1-3 additional heteroatoms selected from N, O and S, where any carbon or sulfur ring atom may optionally be oxidized, each cycle substituted with 0-3  $R^d$ ; and where s is 0-2; B is selected from the group



- 15 where



is a fused hetero- or homocyclic ring containing 5, 6 or 7 atoms, the ring being unsaturated, partially saturated or aromatic, the heteroatoms selected from 1-3 O, S and N,

$Y_1$  is selected from CH and  $NR^n$ ;

n is 0-3;

- 20 G is selected from hydrogen and  $C_1-C_6$  alkyl, optionally G taken together with T may form a  $C_3-C_6$  cycloalkyl optionally substituted with -V-W;

T is selected from the group

a naturally occurring  $\alpha$ -amino-acid side chain,

and U-Q-V-W;

- 25 U is an optionally substituted bivalent radical selected from the group

$C_1-C_6$  alkyl,

$C_0-C_6$  alkyl-Q,



$C_2-C_6$  alkenyl-Q, and

$C_2-C_6$  alkynyl-Q;

where the substituents on any alkyl, alkenyl or alkynyl are 1-3  $R^a$ ;

Q is absent or is selected from the group

- 5        -O-,  
           -S(O)<sub>s</sub>-,  
           -SO<sub>2</sub>-N(R<sup>n</sup>)-,  
           -N(R<sup>n</sup>)-,  
           -N(R<sup>n</sup>)-C(=O)-,  
 10        -N(R<sup>n</sup>)-C(=O)-N(R<sup>n</sup>)-,  
           -N(R<sup>n</sup>)-C(=O)-O-,  
           -N(R<sup>n</sup>)-SO<sub>2</sub>-,  
           -C(=O)-,  
           -C(=O)-O-,  
 15        -het-,  
           -C(=O)-N(R<sup>n</sup>)-,  
           -O-C(=O)-N(R<sup>n</sup>)-,  
           -PO(OR<sup>c</sup>)O- and  
           -P(O)O-;

20        where

s is 0-2 and

het is a mono- or bicyclic 5, 6, 7, 9 or 10 member heterocyclic ring, each ring containing 1-4 heteroatoms selected from N, O and S, where the heterocyclic ring may be saturated, partially saturated, or aromatic and any N or S being optionally oxidized, the heterocyclic ring being

25        substituted with 0-3  $R^h$ ;

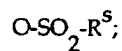
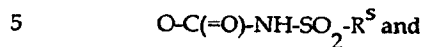
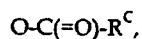
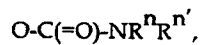
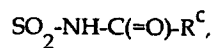
V is absent or is an optionally substituted bivalent group selected from

- $C_1-C_6$  alkyl,  
            $C_3-C_8$  cycloalkyl,  
            $C_0-C_6$  alkyl- $C_6-C_{10}$  aryl, and  
 30         $C_0-C_6$  alky-het;

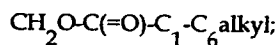
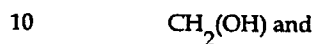
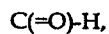
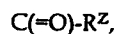
where the substituents on any alkyl are 1-3 R<sup>a</sup> and the substituents on any aryl or het are 1-3 R<sup>d</sup>;

W is selected from the group

- hydrogen,
- 5      OR<sup>o</sup>,
- SR<sup>m</sup>,
- NR<sup>n</sup>R<sup>n'</sup>,
- NH-C(=O)-O-R<sup>c</sup>,
- NH-C(=O)-NR<sup>n</sup>R<sup>n'</sup>,
- 10      NH-C(=O)-R<sup>c</sup>,
- NH-SO<sub>2</sub>-R<sup>s</sup>,
- NH-SO<sub>2</sub>-NR<sup>n</sup>R<sup>n'</sup>,
- NH-SO<sub>2</sub>-NH-C(=O)-R<sup>c</sup>,
- NH-C(=O)-NH-SO<sub>2</sub>-R<sup>s</sup>,
- 15      C(=O)-NH-C(=O)-O-R<sup>c</sup>,
- C(=O)-NH-C(=O)-R<sup>c</sup>,
- C(=O)-NH-C(=O)-NR<sup>n</sup>R<sup>n'</sup>,
- C(=O)-NH-SO<sub>2</sub>-R<sup>s</sup>,
- C(=O)-NH-SO<sub>2</sub>-NR<sup>n</sup>R<sup>n'</sup>,
- 20      C(=S)-NR<sup>n</sup>R<sup>n'</sup>,
- SO<sub>2</sub>-R<sup>s</sup>,
- SO<sub>2</sub>-O-R<sup>s</sup>,
- SO<sub>2</sub>-NR<sup>n</sup>R<sup>n'</sup>,
- SO<sub>2</sub>-NH-C(=O)-O-R<sup>c</sup>,
- 25      SO<sub>2</sub>-NH-C(=O)-NR<sup>n</sup>R<sup>n'</sup>,



R is selected from



$\text{R}^a$  is  $\text{R}^{a'}$  or  $\text{R}^{a''}$  substituted with 1-3  $\text{R}^{a'}$ ; where

$\text{R}^{a'}$  is selected from the group

hydrogen,

15 halo(F, Cl, Br, I),

cyano,

isocyanate,

carboxy,

carboxy- $\text{C}_1\text{-C}_{11}$  alkyl,

20 amino,

amino- $\text{C}_1\text{-C}_8$  alkyl,

aminocarbonyl,

carboxamido,

carbamoyl,

25 carbamoyloxy,

formyl,

formyloxy,

azido,

nitro,

30 imidazolyl,

ureido,

thioureido,

thiocyanato,  
hydroxy,  
 $C_1-C_6$  alkoxy,  
mercapto,  
5 sulfonamido,  
het,  
phenoxy,  
phenyl,  
benzamido,  
10 tosyl,  
morpholino,  
morpholinyl,  
piperazinyl,  
piperidinyl,  
15 pyrrolinyl,  
imidazolyl and  
indolyl;

$R^{a''}$  is selected from the group

$C_0-C_{10}$  alkyl-Q- $C_0-C_6$  alkyl,  
20  $C_0-C_{10}$  alkenyl-Q- $C_0-C_6$  alkyl,  
 $C_0-C_{10}$  alkynyl-Q- $C_0-C_6$  alkyl,  
 $C_3-C_{11}$  cycloalkyl-Q- $C_0-C_6$  alkyl,  
 $C_3-C_{10}$  cycloalkenyl-Q- $C_0-C_6$  alkyl,  
 $C_1-C_6$  alkyl- $C_6-C_{12}$  aryl-Q- $C_0-C_6$  alkyl,  
25  $C_6-C_{10}$  aryl- $C_1-C_6$  alkyl-Q- $C_0-C_6$  alkyl,  
 $C_0-C_6$  alkyl-het-Q- $C_0-C_6$  alkyl,  
 $C_0-C_6$  alkyl-Q-het- $C_0-C_6$  alkyl,  
het- $C_0-C_6$  alkyl-Q- $C_0-C_6$  alkyl,  
 $C_0-C_6$  alkyl-Q- $C_6-C_{12}$  aryl and  
30 -Q- $C_1-C_6$  alkyl;

$R^c$  is selected from hydrogen and substituted or unsubstituted

$C_1-C_{10}$  alkyl,

- $C_2-C_{10}$  alkenyl,  
 $C_2-C_{10}$  alkynyl,  
 $C_3-C_{11}$  cycloalkyl,  
 $C_3-C_{10}$  cycloalkenyl,  
5  $C_1-C_6$  alkyl- $C_6-C_{12}$  aryl,  
 $C_6-C_{10}$  aryl- $C_1-C_6$  alkyl,  
 $C_1-C_6$  alkyl-het,  
het- $C_1-C_6$  alkyl,  
 $C_6-C_{12}$  aryl and  
10 het,

where the substituents on any alkyl, alkenyl or alkynyl are 1-3  $R^a$  and the substituents on any aryl or het are 1-3  $R^d$ ;

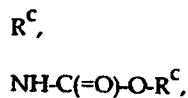
$R^d$  is selected from  $R^P$  and  $R^h$ ;

$R^h$  is selected from the group

- 15 OH,  
 $OCF_3$ ,  
 $OR^c$ ,  
 $SR^m$ ,  
halo(F, Cl, Br, I),  
20 CN,  
isocyanate,  
 $NO_2$ ,  
 $CF_3$ ,  
 $C_0-C_6$  alkyl- $NR^nR^{n'}$ ,  
25  $C_0-C_6$  alkyl-C(=O)- $NR^nR^{n'}$ ,  
 $C_0-C_6$  alkyl-C(=O)- $R^a$ ,  
 $C_1-C_8$  alkyl,  
 $C_1-C_8$  alkoxy,

- $C_2-C_8$  alkenyl,  
 $C_2-C_8$  alkynyl,  
 $C_3-C_6$  cycloalkyl,  
 $C_3-C_6$  cycloalkenyl,  
5  $C_1-C_6$  alkyl-phenyl,  
phenyl- $C_1-C_6$  alkyl,  
 $C_1-C_6$  alkyloxycarbonyl,  
phenyl- $C_0-C_6$  alkyloxy,  
 $C_1-C_6$  alkyl-het,  
10 het- $C_1-C_6$  alkyl,  
 $SO_2$ -het,  
 $-O-C_6-C_{12}$  aryl,  
 $-SO_2-C_6-C_{12}$  aryl,  
 $-SO_2-C_1-C_6$  alkyl and  
15 het,
- where any alkyl, alkenyl or alkynyl may optionally be substituted with 1-3 groups selected from OH, halo(F, Cl, Br, I), nitro, amino and aminocarbonyl and the substituents on any aryl or het are 1-2 hydroxy, halo(F, Cl, Br, I),  $CF_3$ ,  $C_1-C_6$  alkyl,  $C_1-C_6$  alkoxy, nitro and amino;
- $R^m$  is selected from
- 20  $S-C_1-C_6$  alkyl,  
 $C(=O)-C_1-C_6$  alkyl,  
 $C(=O)-NR^nR^{n'}$ ,  
 $C_1-C_6$  alkyl,  
halo(F, Cl, Br, I)- $C_1-C_6$  alkyl,  
25 benzyl and  
phenyl;

$R^n$  is selected from the group



- $\text{NH-C(=O)-R}^c$ ,  
 $\text{NH-C(=O)-NHR}^c$ ,  
 $\text{NH-SO}_2\text{-R}^s$ ,  
 $\text{NH-SO}_2\text{-NH-C(=O)-R}^c$ ,  
5  $\text{NH-C(=O)-NH-SO}_2\text{-R}^s$ ,  
 $\text{C(=O)-O-R}^c$ ,  
 $\text{C(=O)-R}^c$ ,  
 $\text{C(=O)-NHR}^c$ ,  
 $\text{C(=O)-NH-C(=O)-O-R}^c$ ,  
10  $\text{C(=O)-NH-C(=O)-R}^c$ ,  
 $\text{C(=O)-NH-SO}_2\text{-R}^s$ ,  
 $\text{C(=O)-NH-SO}_2\text{-NHR}^s$ ,  
 $\text{SO}_2\text{-R}^s$ ,  
 $\text{SO}_2\text{-O-R}^s$ ,  
15  $\text{SO}_2\text{-N(R}^c)_2$ ,  
 $\text{SO}_2\text{-NH-C(=O)-O-R}^c$ ,  
 $\text{SO}_2\text{-NH-C(=O)-O-R}^c$  and  
 $\text{SO}_2\text{-NH-C(=O)-R}^c$ ;
- $\text{R}^{n'}$  is selected from hydrogen, hydroxy and substituted or unsubstituted  
20  $\text{C}_1\text{-C}_{11}$  alkyl,  
 $\text{C}_1\text{-C}_{11}$  alkoxy,  
 $\text{C}_2\text{-C}_{10}$  alkenyl,  
 $\text{C}_2\text{-C}_{10}$  alkynyl,  
 $\text{C}_3\text{-C}_{11}$  cycloalkyl,  
25  $\text{C}_3\text{-C}_{10}$  cycloalkenyl,

- $C_1-C_6$ alkyl- $C_6-C_{12}$ aryl,  
 $C_6-C_{10}$ aryl- $C_1-C_6$ alkyl,  
 $C_6-C_{10}$ aryl- $C_0-C_6$ alkyloxy,  
 $C_1-C_6$ alkyl-het,  
5    het- $C_1-C_6$ alkyl,  
 $C_6-C_{12}$ aryl,  
het,  
 $C_1-C_6$ alkylcarbonyl,  
 $C_1-C_8$ alkoxycarbonyl,  
10     $C_3-C_8$ cycloalkylcarbonyl,  
 $C_3-C_8$ cycloalkoxycarbonyl,  
 $C_6-C_{11}$ aryloxycarbonyl,  
 $C_7-C_{11}$ arylalkoxycarbonyl,  
heteroarylalkoxycarbonyl,  
15    heteroarylalkylcarbonyl,  
heteroarylcarbonyl,  
heteroarylalkylsulfonyl,  
heteroarylsulfonyl,  
 $C_1-C_6$ alkylsulfonyl and  
20     $C_6-C_{10}$ arylsulfonyl,

where the substituents on any alkyl, alkenyl or alkynyl are 1-3  $R^a$  and the substituents on any aryl, het or heteroaryl are 1-3  $R^d$ ;

$R^n$  and  $R^{n'}$  taken together with the common nitrogen to which they are attached may form an optionally substituted heterocycle selected from

- 25    morpholinyl,  
piperazinyl,  
thiamorpholinyl,  
pyrrolidinyl,  
imidazolidinyl,  
30    indolinyl,  
isoindolinyl,  
1,2,3,4-tetrahydro-quinolinyl,



1,2,3,4-tetrahydro-isoquinoliny,  
thiazolidinyl and  
azabicyclononyl,

where the substituents are 1-3 R<sup>a</sup>;

5 R<sup>O</sup> is selected from hydrogen and substituted or unsubstituted

C<sub>1</sub>-C<sub>6</sub> alkyl,

C<sub>1</sub>-C<sub>6</sub> alkylcarbonyl,

C<sub>2</sub>-C<sub>6</sub> alkenyl,

C<sub>2</sub>-C<sub>6</sub> alkynyl,

10 C<sub>3</sub>-C<sub>8</sub> cycloalkyl and  
benzoyl,

where the substituents on any alkyl are 1-3 R<sup>a</sup> and the substituents on any aryl are 1-3 R<sup>P</sup>;

R<sup>P</sup> is selected from the group

OH,

15 halo(F, Cl, Br, I),

CN,

isocyanate,

OR<sup>c</sup>,

SR<sup>m</sup>,

20 SOR<sup>c</sup>,

NO<sub>2</sub>,

CF<sub>3</sub>,

R<sup>c</sup>,

NR<sup>n</sup>R<sup>n'</sup>,

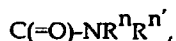
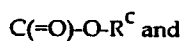
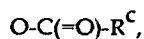
25 NR<sup>n</sup>C(=O)-O-R<sup>c</sup>,

NR<sup>n</sup>C(=O)-R<sup>c</sup>,

C<sub>0</sub>-C<sub>6</sub> alkyl-SO<sub>2</sub>-R<sup>c</sup>,

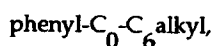
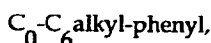
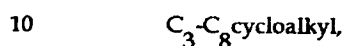
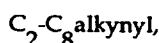
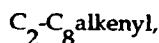
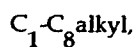
C<sub>0</sub>-C<sub>6</sub> alkyl-SO<sub>2</sub>-NR<sup>n</sup>R<sup>n'</sup>,

C(=O)-R<sup>c</sup>,



where the substituents on any alkyl, alkenyl or alkynyl are 1-3  $\text{R}^{\text{a}}$  and the substituents on  
 5 any aryl or het are 1-3  $\text{R}^{\text{d}}$ ;

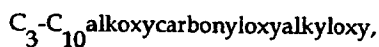
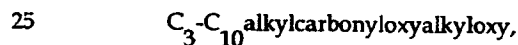
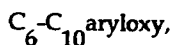
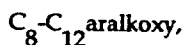
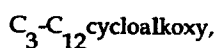
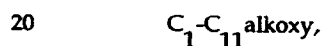
$\text{R}^{\text{s}}$  is a substituted or unsubstituted group selected from



where the substituents on any alkyl, alkenyl or alkynyl are 1-3  $\text{R}^{\text{a}}$  and the substituents on  
 any aryl or het are 1-3  $\text{R}^{\text{d}}$ ;

$\text{R}^{\text{z}}$  is a substituted or unsubstituted group selected from

hydroxy,



$C_5-C_{10}$  cycloalkoxycarbonyloxyalkyloxy,

$C_5-C_{10}$  cycloalkoxycarbonylalkyloxy,

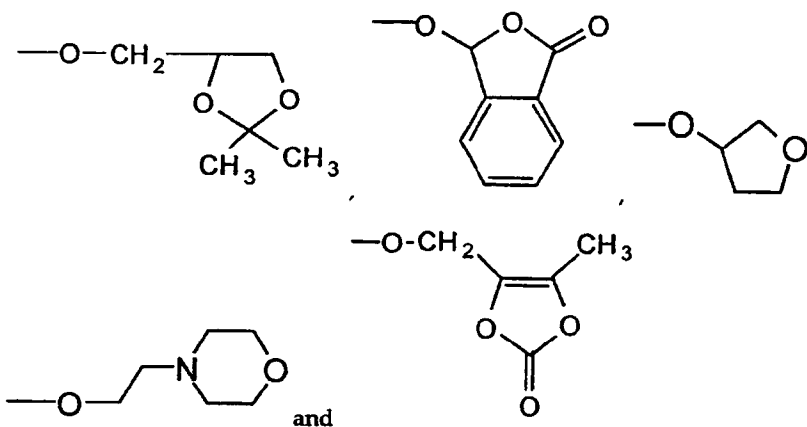
$C_8-C_{12}$  aryloxy carbonylalkyloxy,

$C_8-C_{12}$  aryloxy carbonyloxyalkyloxy,

5  $C_8-C_{12}$  aryl carbonyloxyalkyloxy,

$C_5-C_{10}$  alkoxyalkyl carbonyloxyalkyloxy,

$(R^n)(R^{n'})N(C_1-C_{10} \text{ alkoxy})-$

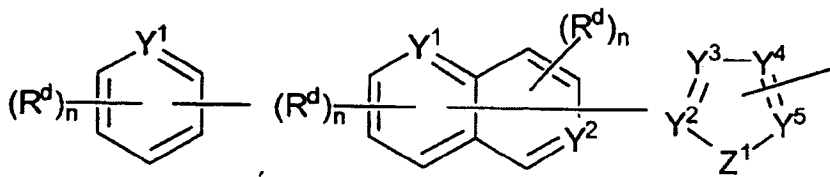


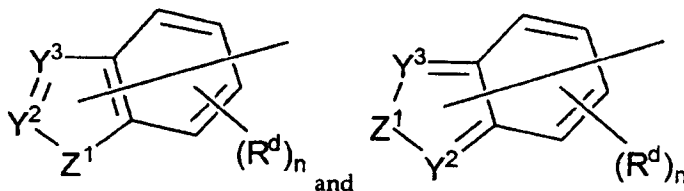
10

where the substituents on any alkyl, alkenyl or alkynyl are 1-3  $R^a$  and the substituents on any aryl or het are 1-3  $R^d$  and pharmaceutically acceptable salts thereof.

2) The method of Claim 1 wherein

15 D is an aromatic homocycle or aromatic heterocycle containing 1-3 heteroatoms selected from the group N, S and O, the homo- or heterocycles selected from the group





where

Y<sup>1</sup>, Y<sup>2</sup>, Y<sup>3</sup>, Y<sup>4</sup> and Y<sup>5</sup> are selected from the group CH, CR<sup>d</sup> and N,

Z<sup>1</sup> is selected from the group O, S, N and NR<sup>n</sup>,

5 n is 0-3,

R<sup>d</sup> is selected from the group

OH, OCF<sub>3</sub>, OR<sup>c</sup>, SR<sup>m</sup>, halo(F, Cl, Br, I), CN, isocyanate, NO<sub>2</sub>, CF<sub>3</sub>, C<sub>0</sub>-C<sub>6</sub>alkyl-NR<sup>n</sup>R<sup>n'</sup>, C<sub>0</sub>-C<sub>6</sub>alkyl-C(=O)-NR<sup>n</sup>R<sup>n'</sup>, C<sub>0</sub>-C<sub>6</sub>alkyl-C(=O)-R<sup>a</sup>, C<sub>1</sub>-C<sub>8</sub>alkyl, C<sub>1</sub>-C<sub>8</sub>alkoxy, C<sub>2</sub>-C<sub>8</sub>alkenyl, C<sub>2</sub>-C<sub>8</sub>alkynyl, C<sub>3</sub>-C<sub>6</sub>cycloalkyl, C<sub>3</sub>-C<sub>6</sub>cycloalkenyl, C<sub>1</sub>-C<sub>6</sub>alkyl-phenyl, phenyl-C<sub>1</sub>-C<sub>6</sub>alkyl, C<sub>1</sub>-C<sub>6</sub>alkyloxycarbonyl, phenyl-C<sub>0</sub>-C<sub>6</sub>alkyloxy, C<sub>1</sub>-C<sub>6</sub>alkyl-het, het-C<sub>1</sub>-C<sub>6</sub>alkyl, SO<sub>2</sub>-het, -O-C<sub>6</sub>-C<sub>12</sub>aryl, -SO<sub>2</sub>-C<sub>6</sub>-C<sub>12</sub>aryl, -SO<sub>2</sub>-C<sub>1</sub>-C<sub>6</sub>alkyl and het, where any alkyl, alkenyl or alkynyl may optionally be substituted with 1-3 groups selected from OH, halo(F, Cl, Br, I), nitro, amino and aminocarbonyl and the substituents on any aryl or het are 1-2 hydroxy, halo(F, Cl, Br, I), CF<sub>3</sub>, C<sub>1</sub>-C<sub>6</sub>alkyl, C<sub>1</sub>-C<sub>6</sub>alkoxy, nitro and amino;

15 R<sup>a</sup> is R<sup>a'</sup> or R<sup>a''</sup> substituted with 1-3 R<sup>a'</sup>; where

R<sup>a'</sup> is selected from the group

hydrogen, halo(F, Cl, Br, I), cyano, isocyanate, carboxy, carboxy-C<sub>1</sub>-C<sub>11</sub>alkyl, amino, amino-C<sub>1</sub>-C<sub>8</sub>alkyl, aminocarbonyl, carboxamido, carbamoyl, carbamoyloxy, formyl, formyloxy, azido, nitro, imidazolyl, ureido, thioureido, thiocyanato, hydroxy, C<sub>1</sub>-C<sub>6</sub>alkoxy, mercapto, sulfonamido, het, phenoxy, phenyl, benzamido, tosyl, morpholino, morpholinyl, piperazinyl, piperidinyl, pyrrolinyl, imidazolyl and indolyl;

R<sup>a''</sup> is selected from the group

C<sub>0</sub>-C<sub>10</sub>alkyl-Q-C<sub>0</sub>-C<sub>6</sub>alkyl, C<sub>0</sub>-C<sub>10</sub>alkenyl-Q-C<sub>0</sub>-C<sub>6</sub>alkyl, C<sub>0</sub>-C<sub>10</sub>alkynyl-Q-C<sub>0</sub>-C<sub>6</sub>alkyl, C<sub>3</sub>-C<sub>11</sub>cycloalkyl-Q-C<sub>0</sub>-C<sub>6</sub>alkyl, C<sub>3</sub>-C<sub>10</sub>cycloalkenyl-Q-C<sub>0</sub>-C<sub>6</sub>alkyl, C<sub>1</sub>-C<sub>6</sub>alkyl-C<sub>6</sub>-C<sub>12</sub>aryl-Q-C<sub>0</sub>-C<sub>6</sub>alkyl, C<sub>6</sub>-C<sub>10</sub>aryl-C<sub>1</sub>-C<sub>6</sub>alkyl-Q-C<sub>0</sub>-C<sub>6</sub>alkyl, C<sub>0</sub>-C<sub>6</sub>alkyl-het-Q-C<sub>0</sub>-

$C_6$  alkyl,  $C_0$ - $C_6$  alkyl-Q-het- $C_0$ - $C_6$  alkyl, het- $C_0$ - $C_6$  alkyl-Q- $C_0$ - $C_6$  alkyl,  $C_0$ - $C_6$  alkyl-Q- $C_6$ - $C_{12}$  aryl and -Q- $C_1$ - $C_6$  alkyl;

Q is absent or is selected from the group

- O-, -S(O)<sub>s</sub>-, -SO<sub>2</sub>-N(R<sup>n</sup>)-, -N(R<sup>n</sup>)-SO<sub>2</sub>-, -N(R<sup>n</sup>)-C(=O)-, -C(=O)-N(R<sup>n</sup>)-, -N(R<sup>n</sup>)-C(=O)-O-, -O-C(=O)-N(R<sup>n</sup>)-, -N(R<sup>n</sup>)-C(=O)-N(R<sup>n</sup>)-, -C(=O)-, -N(R<sup>n</sup>)-, -C(=O)-O-, -O-C(=O)-, -het-, -PO(OR<sup>c</sup>)O- and -P(O)O-, where s is 0-2; het is a mono- or bicyclic 5, 6, 7, 9 or 10 member heterocyclic ring, each ring containing 1-4 heteroatoms selected from N, O and S, where the heterocyclic ring may be saturated, partially saturated, or aromatic and any N or S being optionally oxidized, the heterocyclic ring being substituted with 0-3 hydroxy, halo(F, Cl, Br, I), CF<sub>3</sub>,  $C_1$ - $C_6$  alkyl,  $C_1$ - $C_6$  alkoxy, nitro and amino;

R<sup>c</sup> is selected from hydrogen and substituted or unsubstituted

- $C_1$ - $C_{10}$  alkyl,  $C_2$ - $C_{10}$  alkenyl,  $C_2$ - $C_{10}$  alkynyl,  $C_3$ - $C_{11}$  cycloalkyl,  $C_3$ - $C_{10}$  cycloalkenyl,  $C_1$ - $C_6$  alkyl- $C_6$ - $C_{12}$  aryl,  $C_6$ - $C_{10}$  aryl- $C_1$ - $C_6$  alkyl,  $C_1$ - $C_6$  alkyl-het, het- $C_1$ - $C_6$  alkyl,  $C_6$ - $C_{12}$  aryl and het, where the substituents are 1-3 hydroxy, halo(F, Cl, Br, I), CF<sub>3</sub>,  $C_1$ - $C_6$  alkyl,  $C_1$ - $C_6$  alkoxy, nitro and amino;

R<sup>m</sup> is selected from

S- $C_1$ - $C_6$  alkyl, C(=O)- $C_1$ - $C_6$  alkyl, C(=O)-NR<sup>n</sup>R<sup>n'</sup>,  $C_1$ - $C_6$  alkyl, halo(F, Cl, Br, I)- $C_1$ - $C_6$  alkyl, benzyl and phenyl;

R<sup>n</sup> is selected from the group

- R<sup>c</sup>, NH-C(=O)-O-R<sup>c</sup>, NH-C(=O)-R<sup>c</sup>, NH-C(=O)-NHR<sup>c</sup>, NH-SO<sub>2</sub>-R<sup>s</sup>, NH-SO<sub>2</sub>-NH-C(=O)-R<sup>c</sup>, NH-C(=O)-NH-SO<sub>2</sub>-R<sup>s</sup>, C(=O)-O-R<sup>c</sup>, C(=O)-R<sup>c</sup>, C(=O)-NHR<sup>c</sup>, C(=O)-NH-C(=O)-O-R<sup>c</sup>, C(=O)-NH-C(=O)-R<sup>c</sup>, C(=O)-NH-SO<sub>2</sub>-R<sup>s</sup>, C(=O)-NH-SO<sub>2</sub>-NHR<sup>s</sup>, SO<sub>2</sub>-R<sup>s</sup>, SO<sub>2</sub>-O-R<sup>s</sup>, SO<sub>2</sub>-N(R<sup>c</sup>)<sub>2</sub>, SO<sub>2</sub>-NH-C(=O)-O-R<sup>c</sup>, SO<sub>2</sub>-NH-C(=O)-O-R<sup>c</sup> and SO<sub>2</sub>-NH-C(=O)-R<sup>c</sup>;

R<sup>n'</sup> is selected from hydrogen, hydroxy and substituted or unsubstituted

- $C_1$ - $C_{11}$  alkyl,  $C_1$ - $C_{11}$  alkoxy,  $C_2$ - $C_{10}$  alkenyl,  $C_2$ - $C_{10}$  alkynyl,  $C_3$ - $C_{11}$  cycloalkyl,  $C_3$ - $C_{10}$  cycloalkenyl,  $C_1$ - $C_6$  alkyl- $C_6$ - $C_{12}$  aryl,  $C_6$ - $C_{10}$  aryl- $C_1$ - $C_6$  alkyl,  $C_6$ - $C_{10}$  aryl- $C_0$ - $C_6$  alkoxy,  $C_1$ - $C_6$  alkyl-het, het- $C_1$ - $C_6$  alkyl,  $C_6$ - $C_{12}$  aryl, het,  $C_1$ - $C_6$  alkylcarbonyl,  $C_1$ - $C_8$  alkoxy carbonyl,  $C_3$ - $C_8$  cycloalkylcarbonyl,  $C_3$ - $C_8$  cycloalkoxy carbonyl,  $C_6$ -

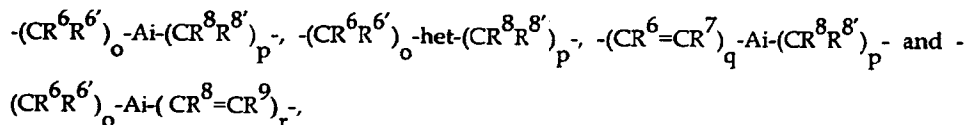
$C_{11}$  aryloxy carbonyl,  $C_7$ - $C_{11}$  arylalkoxy carbonyl, heteroarylalkoxy carbonyl, heteroarylalkyl carbonyl, heteroaryl carbonyl, heteroarylalkyl sulfonyl, heteroaryl sulfonyl,  $C_1$ - $C_6$  alkyl sulfonyl and  $C_6$ - $C_{10}$  aryl sulfonyl, where any alkyl, alkenyl or alkynyl may optionally be substituted with 1-3 groups selected from OH, halo(F, Cl, Br, I), nitro, amino and aminocarbonyl and the substituents on any aryl, heteroaryl or het are 1-2 hydroxy, halo(F, Cl, Br, I),  $CF_3$ ,  $C_1$ - $C_6$  alkyl,  $C_1$ - $C_6$  alkoxy, nitro and amino;

$R^n$  and  $R^{n'}$  taken together with the common nitrogen to which they are attached may form an optionally substituted heterocycle selected from morpholinyl, piperazinyl, thiomorpholinyl, pyrrolidinyl, imidazolidinyl, indolinyl, isoindolinyl, 1,2,3,4-tetrahydro-quinolinyl, 1,2,3,4-tetrahydro-isoquinolinyl, thiazolidinyl and azabicyclononyl, where the substituents are 1-3 hydroxy, halo(F, Cl, Br, I),  $CF_3$ ,  $C_1$ - $C_6$  alkyl,  $C_1$ - $C_6$  alkoxy, nitro and amino;

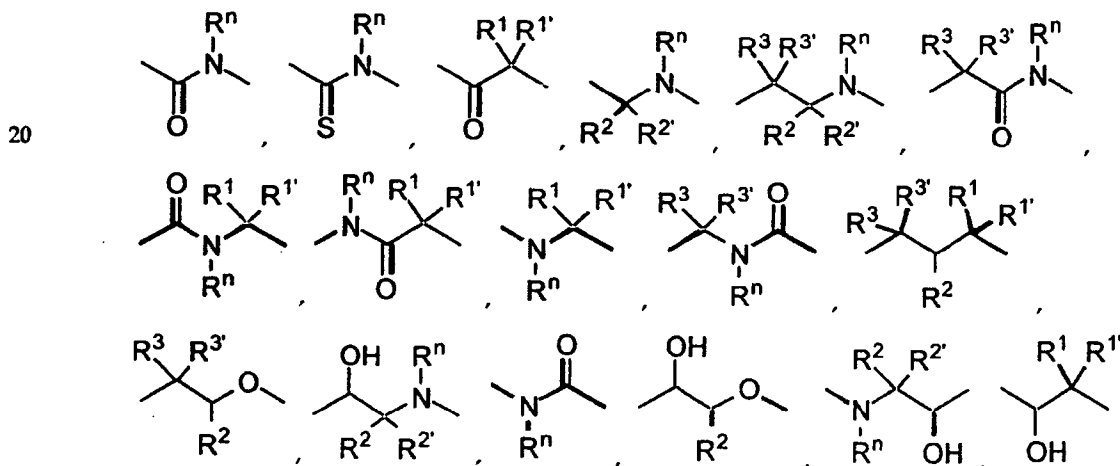
$R^S$  is a substituted or unsubstituted group selected from

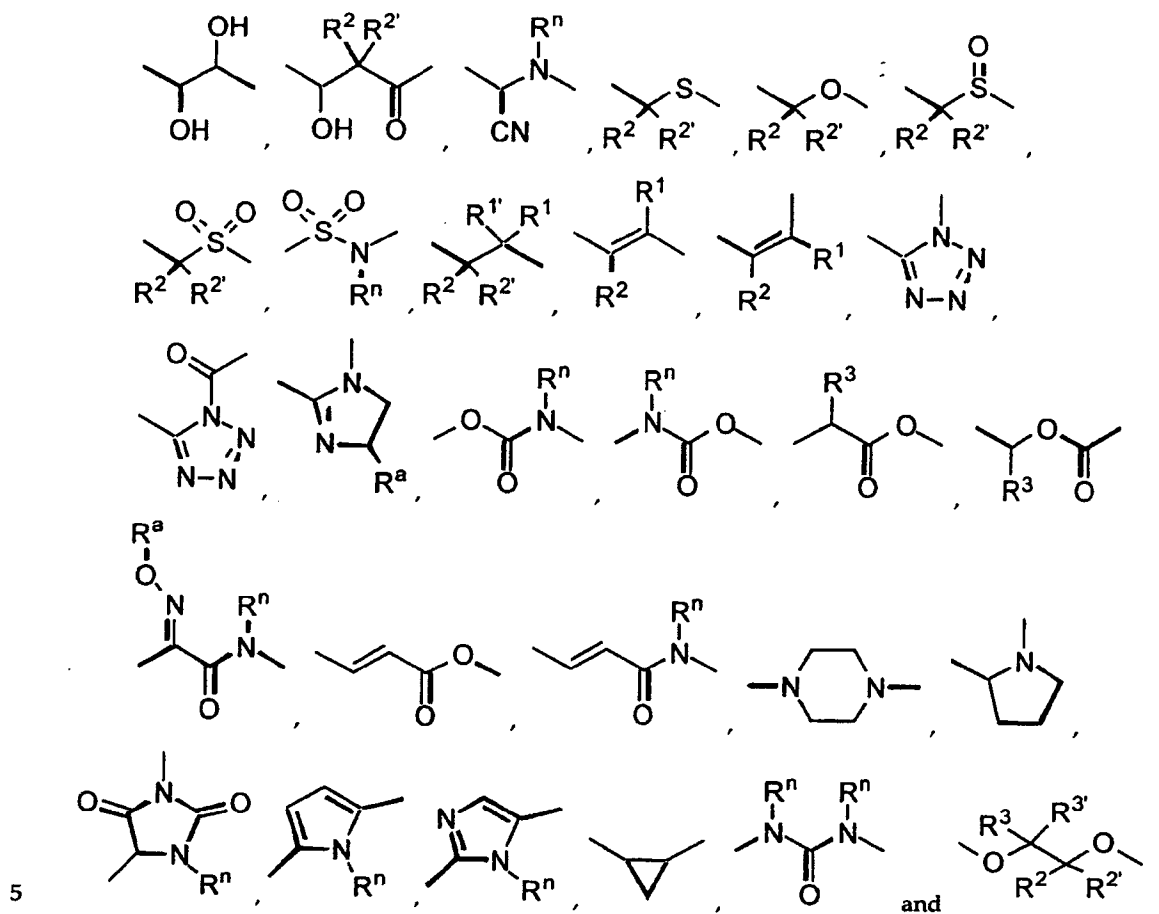
$C_1$ - $C_8$  alkyl,  $C_2$ - $C_8$  alkenyl,  $C_2$ - $C_8$  alkynyl,  $C_3$ - $C_8$  cycloalkyl,  $C_3$ - $C_6$  cycloalkenyl,  $C_0$ - $C_6$  alkyl-phenyl, phenyl- $C_0$ - $C_6$  alkyl,  $C_0$ - $C_6$  alkyl-het and het- $C_0$ - $C_6$  alkyl, where the substituents are 1-3 hydroxy, halo(F, Cl, Br, I),  $CF_3$ ,  $C_1$ - $C_6$  alkyl,  $C_1$ - $C_6$  alkoxy, nitro and amino;

L is selected from the group



where Ai is selected from





$R^C$ ,  $O-C(=O)-NH-C(=O)-R^C$ ,  $O-C(=O)-NH-SO_2-R^S$  and  $O-SO_2-R^S$ ;

G is hydrogen;

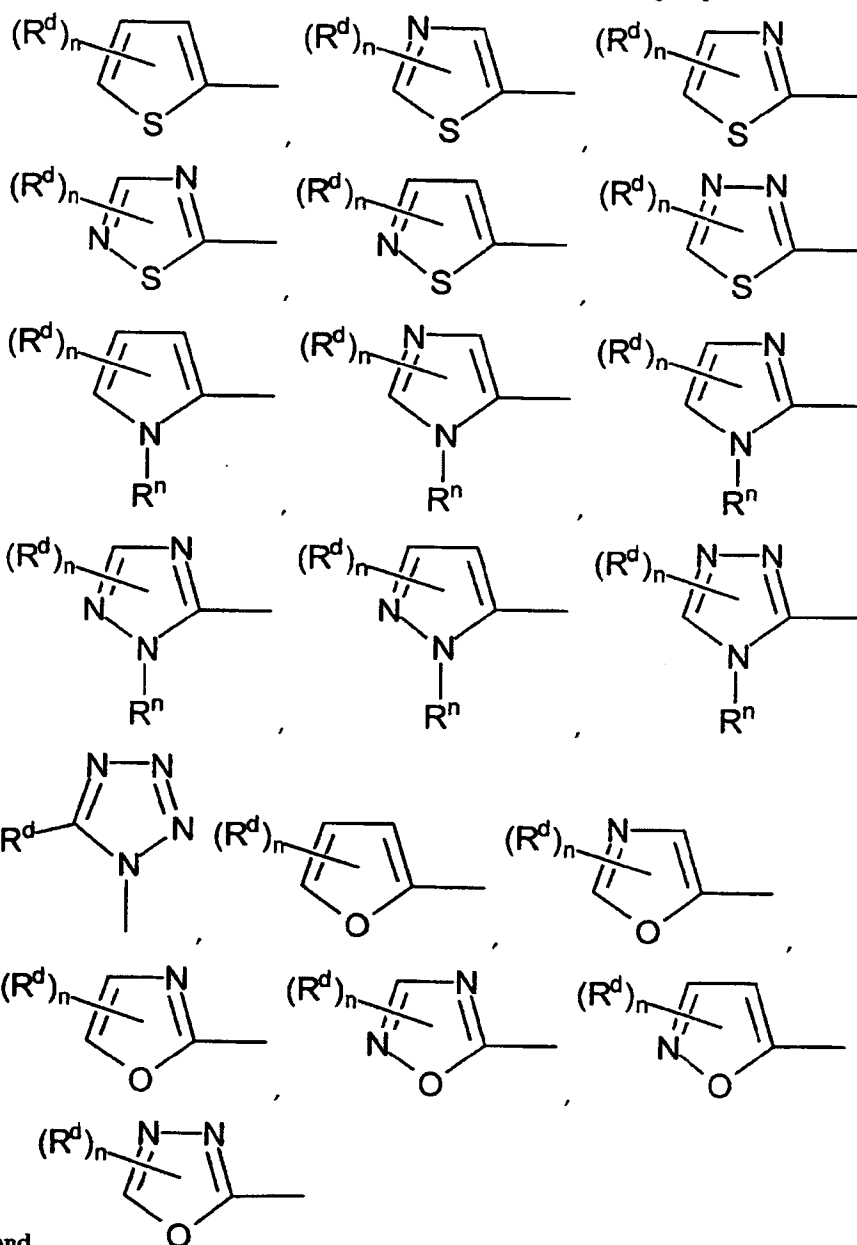
T is U-W;

R is  $C(=O)-OH$  and

5 pharmaceutically acceptable salts thereof.

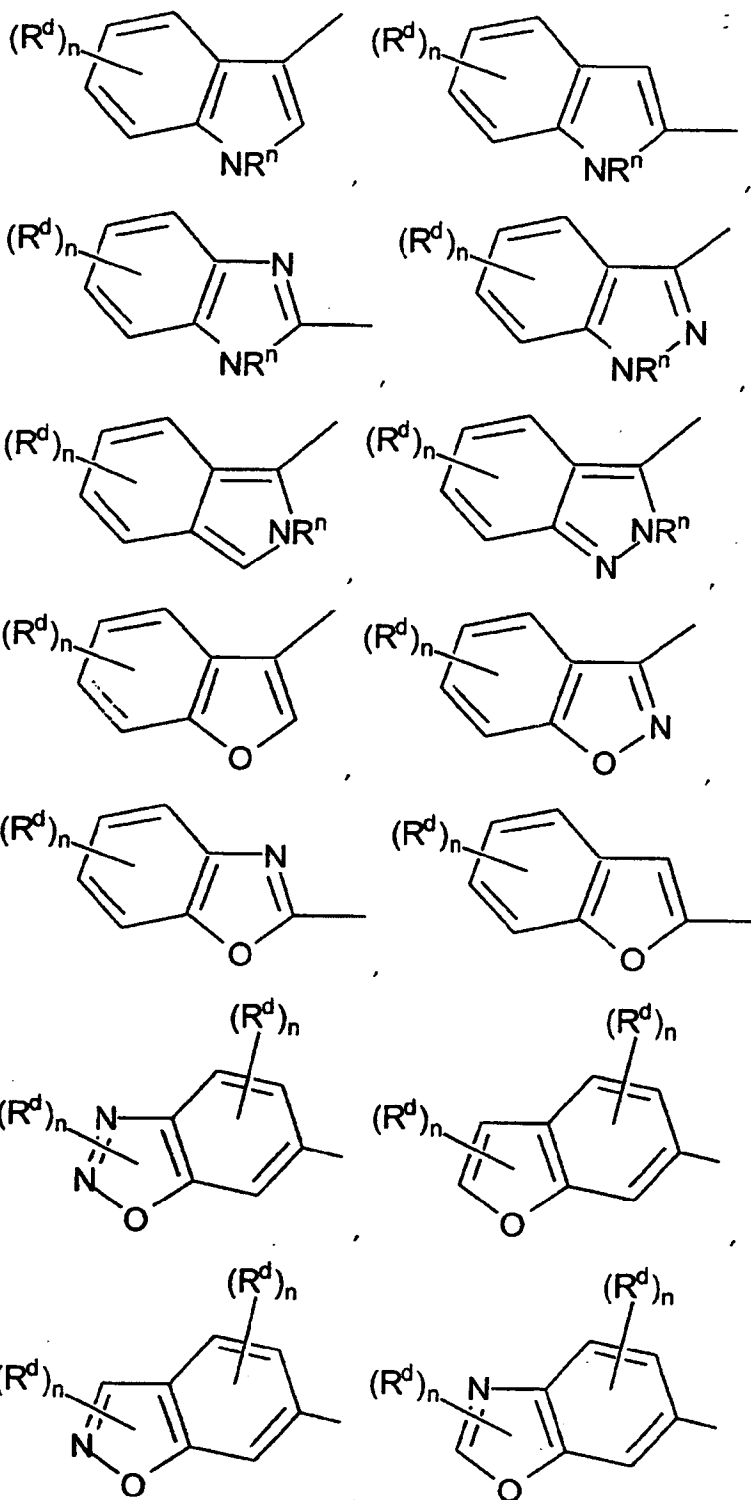
3) The method of Claim 2 wherein D is selected from

1) a 5-member aromatic heterocycle selected from the group

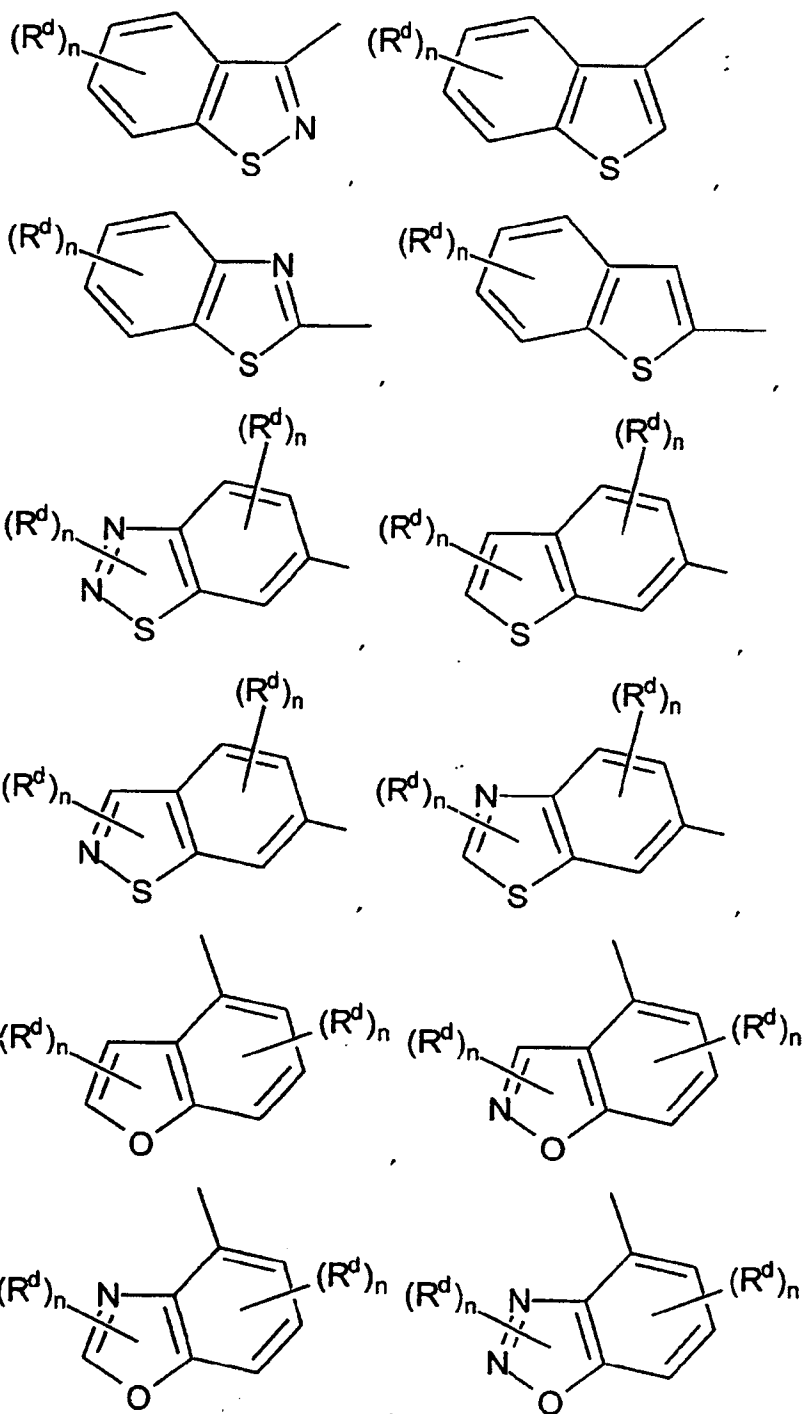




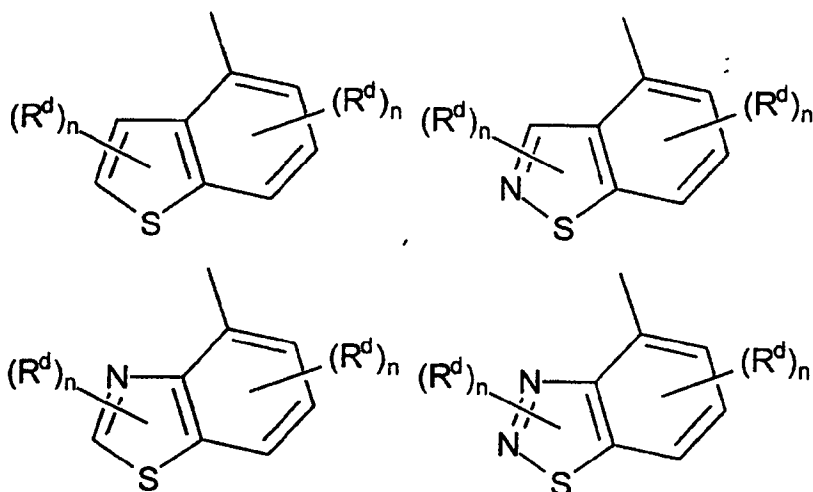
2) a 9-member aromatic heterobicycle selected from the group



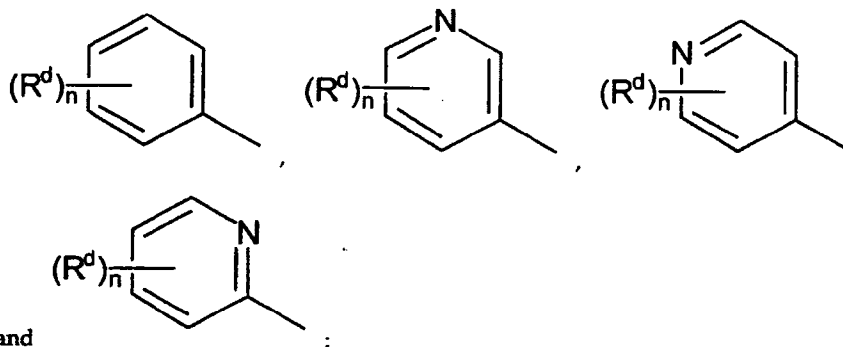
5



5



3) a 6-member aromatic hetero- or homocycle selected from the group



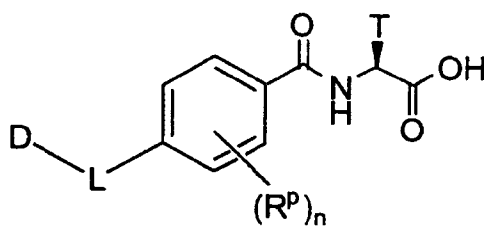
5 and

L is a bivalent linking group selected from the group

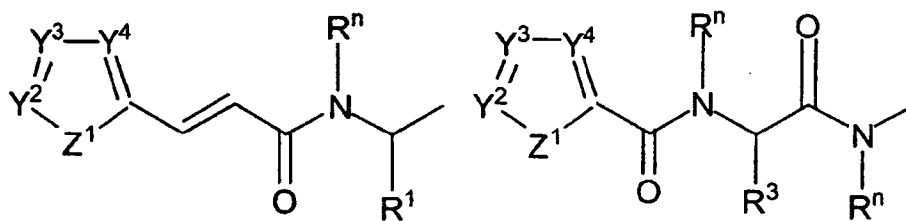
- C<sub>3</sub>-C<sub>5</sub>-alkyl-,
- C<sub>3</sub>-C<sub>5</sub>-alkenyl-,
- CH<sub>2</sub>C(=O)NH-,
- 10 -CH<sub>2</sub>NH-C(=O)-,
- O-CH<sub>2</sub>-C(=O)-,
- CH<sub>2</sub>-CH<sub>2</sub>-C(=O)-,
- CH=CH-C(=O)NH-CH<sub>2</sub>-,
- CH=CH-C(=O)NH-CH(CH<sub>3</sub>)-,
- 15 -CH(OH)-CH<sub>2</sub>-O-,
- CH(OH)-CH<sub>2</sub>-CH<sub>2</sub>-,
- CH<sub>2</sub>-CH<sub>2</sub>-CH(OH)-,

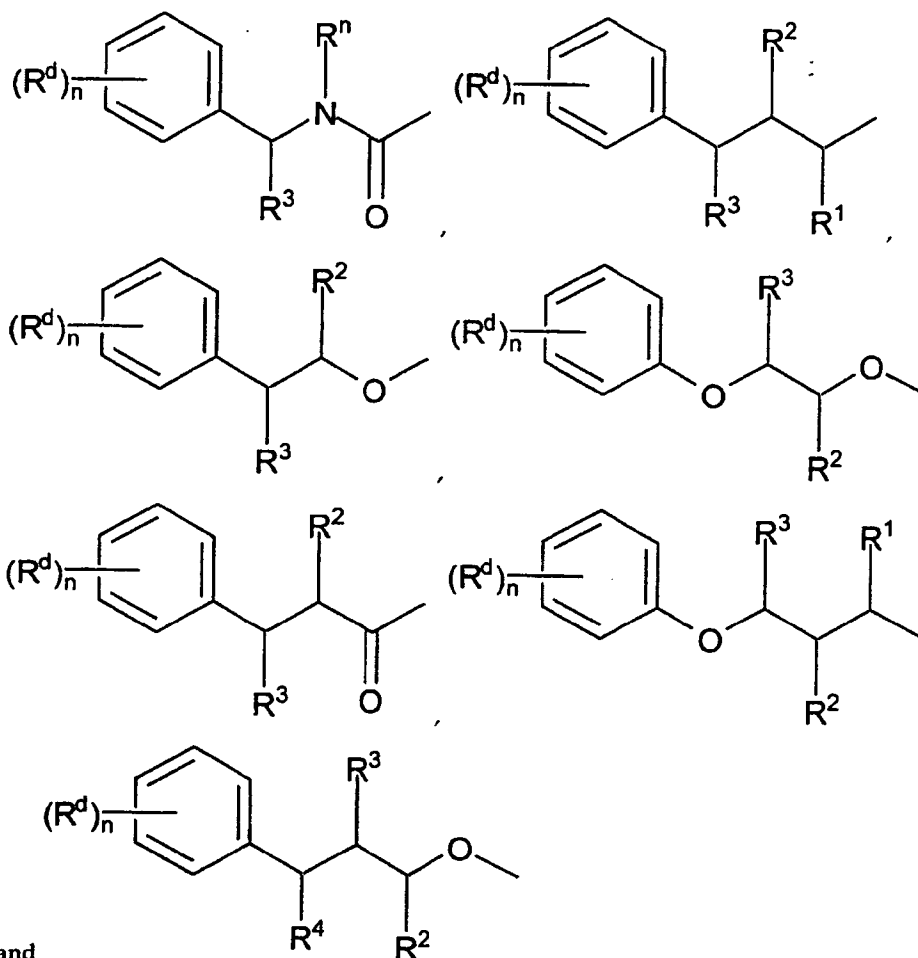
- O-CH<sub>2</sub>-CH(OH)-,  
 -O-CH<sub>2</sub>-CH(OH)-CH<sub>2</sub>-,  
 -O-CH<sub>2</sub>-CH<sub>2</sub>-CH(OH)-,  
 -O-CH<sub>2</sub>-CH<sub>2</sub>-O-,  
 5 -CH<sub>2</sub>-CH<sub>2</sub>-CH<sub>2</sub>-O-,  
 -CH<sub>2</sub>-CH(OH)-CH<sub>2</sub>-O-,  
 -CH<sub>2</sub>-CH<sub>2</sub>-O-,  
 -CH-(CH<sub>3</sub>)-NH-C(=O)-,  
 -CH<sub>2</sub>-NH-SO<sub>2</sub>-,  
 10 -NH-SO<sub>2</sub>-CH<sub>2</sub>-,  
 -CH<sub>2</sub>-SO<sub>2</sub>NH-,  
 -SO<sub>2</sub>NH-CH<sub>2</sub>-,  
 -C(=O)-NH-C(=O)-,  
 -NH-C(=O)-NH-,  
 15 -NH-C(=O)-NH-CH<sub>2</sub>-,  
 -CH<sub>2</sub>-NH-C(=O)-NH-,  
 -C(=O)-NH-CH<sub>2</sub>-C(=O)-NH-,  
 -NH-C(=O)-O- and  
 -O-C(=O)-NH-, and pharmaceutically acceptable salts thereof.

- 20 4) The method of Claim 3 wherein the compound is represented by



where D-L- is selected from





and

5 where

$Y^2, Y^3$  and  $Y^4$  are selected from the group CH,  $CR^d$  and N;

$Z^1$  is selected from the group O, S, NH and  $NR^n$ ;

$n$  is 0-3;

$R^1, R^2$  and  $R^3$  each are independently selected from  $R^a, R^c$  and U-W;

10

U is an optionally substituted bivalent radical selected from the group

$C_1-C_6$ alkyl-,  $C_0-C_6$ alkyl-Q-,  $C_2-C_6$ alkenyl-Q-, and  $C_2-C_6$ alkynyl-Q-, where the substituents

on any alkyl, alkenyl or alkynyl are 1-3  $R^a$ ;

Q is absent or is selected from the group

15  $-O-$ ,  $-S(O)_5-$ ,  $-SO_2-N(R^n)-$ ,  $-N(R^n)-$ ,  $-N(R^n)-C(=O)-$ ,  $-N(R^n)-C(=O)-N(R^n)-$ ,  $-N(R^n)-C(=O)-O-$ ,  
 $-O-C(=O)-N(R^n)-$ ,  $-N(R^n)-SO_2-$ ,  $-C(=O)-$ ,  $-C(=O)-O-$ , -het-,  $-C(=O)-N(R^n)-$ ,  $-PO(OR^c)O-$  and -

P(O)<sub>s</sub>O-, where s is 0-2; het is a mono- or bicyclic 5, 6, 7, 9 or 10 member heterocyclic ring, each ring containing 1-4 heteroatoms selected from N, O and S, where the heterocyclic ring may be saturated, partially saturated, or aromatic and any N or S being optionally oxidized, the heterocyclic ring being substituted with 0-3 hydroxy, halo(F, Cl, Br, I), CF<sub>3</sub>, C<sub>1</sub>-C<sub>6</sub> alkyl,

5 C<sub>1</sub>-C<sub>6</sub> alkoxy, nitro and amino;

W is selected from the group

hydrogen, OH, O-C<sub>1</sub>-C<sub>6</sub> alkyl, SH, SR<sup>m</sup>, NR<sup>n</sup>R<sup>n'</sup>, NH-C(=O)-O-R<sup>c</sup>, NH-C(=O)-NR<sup>n</sup>R<sup>n'</sup>, NH-C(=O)-R<sup>c</sup>, NH-SO<sub>2</sub>-R<sup>s</sup>, NH-SO<sub>2</sub>-NR<sup>n</sup>R<sup>n'</sup>, NH-SO<sub>2</sub>-NH-C(=O)-R<sup>c</sup>, NH-C(=O)-NH-SO<sub>2</sub>-R<sup>s</sup>, C(=O)-NH-C(=O)-O-R<sup>c</sup>, C(=O)-NH-C(=O)-R<sup>c</sup>, C(=O)-NH-C(=O)-NR<sup>n</sup>R<sup>n'</sup>, C(=O)-NH-SO<sub>2</sub>-R<sup>s</sup>, C(=O)-NH-SO<sub>2</sub>-NR<sup>n</sup>R<sup>n'</sup>, C(=S)-NR<sup>n</sup>R<sup>n'</sup>, SO<sub>2</sub>-R<sup>s</sup>, SO<sub>2</sub>-O-R<sup>s</sup>, SO<sub>2</sub>-NR<sup>n</sup>R<sup>n'</sup>, SO<sub>2</sub>-NH-C(=O)-O-R<sup>c</sup>, SO<sub>2</sub>-NH-C(=O)-NR<sup>n</sup>R<sup>n'</sup>, SO<sub>2</sub>-NH-C(=O)-R<sup>c</sup>, O-C(=O)-NR<sup>n</sup>R<sup>n'</sup>, O-C(=O)-R<sup>c</sup>, O-C(=O)-NH-C(=O)-R<sup>c</sup>, O-C(=O)-NH-SO<sub>2</sub>-R<sup>s</sup> and O-SO<sub>2</sub>-R<sup>s</sup>; R<sup>a</sup> is R<sup>a'</sup> or R<sup>a''</sup> substituted with 1-3 R<sup>a'</sup>; where

R<sup>a'</sup> is selected from the group

15 hydrogen, halo(F, Cl, Br, I), cyano, carboxy, carboxy-C<sub>1</sub>-C<sub>11</sub> alkyl, amino, amino-C<sub>1</sub>-C<sub>8</sub> alkyl, aminocarbonyl, carboxamido, carbamoyl, carbamoyloxy, formyl, formyloxy, azido, nitro, imidazolyl, ureido, thioureido, thiocyanato, hydroxy, C<sub>1</sub>-C<sub>6</sub> alkoxy, mercapto, sulfonamido, het, phenoxy, phenyl, benzamido, tosyl, morpholino, morpholinyl, piperazinyl, piperidinyl, pyrrolinyl, imidazolyl and indolyl;

20 R<sup>a''</sup> is selected from the group

C<sub>0</sub>-C<sub>10</sub> alkyl-Q-C<sub>0</sub>-C<sub>6</sub> alkyl, C<sub>0</sub>-C<sub>10</sub> alkenyl-Q-C<sub>0</sub>-C<sub>6</sub> alkyl, C<sub>0</sub>-C<sub>10</sub> alkynyl-Q-C<sub>0</sub>-C<sub>6</sub> alkyl, C<sub>3</sub>-C<sub>11</sub> cycloalkyl-Q-C<sub>0</sub>-C<sub>6</sub> alkyl, C<sub>3</sub>-C<sub>10</sub> cycloalkenyl-Q-C<sub>0</sub>-C<sub>6</sub> alkyl, C<sub>1</sub>-C<sub>6</sub> alkyl-C<sub>6</sub>-C<sub>12</sub> aryl-Q-C<sub>0</sub>-C<sub>6</sub> alkyl, C<sub>6</sub>-C<sub>10</sub> aryl-C<sub>1</sub>-C<sub>6</sub> alkyl-Q-C<sub>0</sub>-C<sub>6</sub> alkyl, C<sub>0</sub>-C<sub>6</sub> alkyl-het-Q-C<sub>0</sub>-C<sub>6</sub> alkyl, C<sub>0</sub>-C<sub>6</sub> alkyl-Q-het-C<sub>0</sub>-C<sub>6</sub> alkyl, het-C<sub>0</sub>-C<sub>6</sub> alkyl-Q-C<sub>0</sub>-C<sub>6</sub> alkyl, C<sub>0</sub>-C<sub>6</sub> alkyl-Q-C<sub>6</sub>-C<sub>12</sub> aryl and -Q-C<sub>1</sub>-C<sub>6</sub> alkyl;

R<sup>c</sup> is selected from hydrogen and substituted or unsubstituted

C<sub>1</sub>-C<sub>10</sub> alkyl, C<sub>2</sub>-C<sub>10</sub> alkenyl, C<sub>2</sub>-C<sub>10</sub> alkynyl, C<sub>3</sub>-C<sub>11</sub> cycloalkyl, C<sub>3</sub>-C<sub>10</sub> cycloalkenyl, C<sub>1</sub>-C<sub>6</sub> alkyl-C<sub>6</sub>-C<sub>12</sub> aryl, C<sub>6</sub>-C<sub>10</sub> aryl-C<sub>1</sub>-C<sub>6</sub> alkyl, C<sub>1</sub>-C<sub>6</sub> alkyl-het, het-C<sub>1</sub>-C<sub>6</sub> alkyl, C<sub>6</sub>-C<sub>12</sub> aryl

and het, where the substituents are 1-3 hydroxy, halo(F, Cl, Br, I),  $\text{CF}_3$ ,  $\text{C}_1\text{-C}_6$  alkyl,  $\text{C}_1\text{-C}_6$  alkoxy, nitro and amino;

$\text{R}^d$  is selected from the group

OH,  $\text{OCF}_3$ ,  $\text{OR}^c$ ,  $\text{SR}^m$ , halo(F, Cl, Br, I), CN,  $\text{NO}_2$ ,  $\text{CF}_3$ ,  $\text{C}_0\text{-C}_6$  alkyl- $\text{NR}^n\text{R}^{n'}$ ,  $\text{C}_0\text{-C}_6$  alkyl-  
 5  $\text{C}(=\text{O})\text{-NR}^n\text{R}^{n'}$ ,  $\text{C}_0\text{-C}_6$  alkyl- $\text{C}(=\text{O})\text{-R}^a$ ,  $\text{C}_1\text{-C}_8$  alkyl,  $\text{C}_1\text{-C}_8$  alkoxy,  $\text{C}_2\text{-C}_8$  alkenyl,  $\text{C}_2\text{-C}_8$  alkynyl,  $\text{C}_3\text{-C}_6$  cycloalkyl,  $\text{C}_3\text{-C}_6$  cycloalkenyl,  $\text{C}_1\text{-C}_6$  alkyl-phenyl, phenyl- $\text{C}_1\text{-C}_6$  alkyl,  $\text{C}_1\text{-C}_6$  alkoxycarbonyl, phenyl- $\text{C}_0\text{-C}_6$  alkoxy,  $\text{C}_1\text{-C}_6$  alkyl-het, het- $\text{C}_1\text{-C}_6$  alkyl,  $\text{SO}_2$ -het, -  
 10  $\text{O-C}_6\text{-C}_{12}$  aryl,  $\text{-SO}_2\text{-C}_6\text{-C}_{12}$  aryl,  $\text{-SO}_2\text{-C}_1\text{-C}_6$  alkyl and het, where any alkyl, alkenyl or alkynyl may optionally be substituted with 1-3 groups selected from OH, halo(F, Cl, Br, I), nitro, amino and aminocarbonyl and the substituents on any aryl or het are 1-2 hydroxy, halo(F, Cl, Br, I),  $\text{CF}_3$ ,  $\text{C}_1\text{-C}_6$  alkyl,  $\text{C}_1\text{-C}_6$  alkoxy, nitro and amino;

$\text{R}^m$  is selected from

$\text{S-C}_1\text{-C}_6$  alkyl,  $\text{C}(=\text{O})\text{-C}_1\text{-C}_6$  alkyl,  $\text{C}(=\text{O})\text{-NR}^n\text{R}^{n'}$ ,  $\text{C}_1\text{-C}_6$  alkyl, halo(F, Cl, Br, I)- $\text{C}_1\text{-C}_6$  alkyl, benzyl and phenyl;

15  $\text{R}^n$  is selected from the group

$\text{R}^c$ ,  $\text{NH-C}(=\text{O})\text{-O-R}^c$ ,  $\text{NH-C}(=\text{O})\text{-R}^c$ ,  $\text{NH-C}(=\text{O})\text{-NHR}^c$ ,  $\text{NH-SO}_2\text{-R}^s$ ,  $\text{NH-SO}_2\text{-NH-C}(=\text{O})\text{-R}^c$ ,  $\text{NH-C}(=\text{O})\text{-NH-SO}_2\text{-R}^s$ ,  $\text{C}(=\text{O})\text{-O-R}^c$ ,  $\text{C}(=\text{O})\text{-R}^c$ ,  $\text{C}(=\text{O})\text{-NHR}^c$ ,  $\text{C}(=\text{O})\text{-NH-C}(=\text{O})\text{-O-R}^c$ ,  $\text{C}(=\text{O})\text{-NH-C}(=\text{O})\text{-R}^c$ ,  $\text{C}(=\text{O})\text{-NH-SO}_2\text{-R}^s$ ,  $\text{C}(=\text{O})\text{-NH-SO}_2\text{-NHR}^s$ ,  $\text{SO}_2\text{-R}^s$ ,  $\text{SO}_2\text{-O-R}^s$ ,  $\text{SO}_2\text{-N(R}^c)_2$ ,  $\text{SO}_2\text{-NH-C}(=\text{O})\text{-O-R}^c$ ,  $\text{SO}_2\text{-NH-C}(=\text{O})\text{-O-R}^c$  and  $\text{SO}_2\text{-NH-C}(=\text{O})\text{-R}^c$ ;

20  $\text{R}^{n'}$  is selected from hydrogen, hydroxy and substituted or unsubstituted

$\text{C}_1\text{-C}_{11}$  alkyl,  $\text{C}_1\text{-C}_{11}$  alkoxy,  $\text{C}_2\text{-C}_{10}$  alkenyl,  $\text{C}_2\text{-C}_{10}$  alkynyl,  $\text{C}_3\text{-C}_{11}$  cycloalkyl,  $\text{C}_3\text{-C}_{10}$  cycloalkenyl,  $\text{C}_1\text{-C}_6$  alkyl- $\text{C}_6\text{-C}_{12}$  aryl,  $\text{C}_6\text{-C}_{10}$  aryl- $\text{C}_1\text{-C}_6$  alkyl,  $\text{C}_6\text{-C}_{10}$  aryl- $\text{C}_0\text{-C}_6$  alkoxy,  $\text{C}_1\text{-C}_6$  alkyl-het, het- $\text{C}_1\text{-C}_6$  alkyl,  $\text{C}_6\text{-C}_{12}$  aryl, het,  $\text{C}_1\text{-C}_6$  alkylcarbonyl,  $\text{C}_1\text{-C}_8$  alkoxycarbonyl,  $\text{C}_3\text{-C}_8$  cycloalkylcarbonyl,  $\text{C}_3\text{-C}_8$  cycloalkoxycarbonyl,  $\text{C}_6\text{-C}_{11}$  aryloxycarbonyl,  $\text{C}_7\text{-C}_{11}$  arylalkoxycarbonyl, heteroarylalkoxycarbonyl, heteroarylalkylcarbonyl, heteroarylcarbonyl, heteroarylalkylsulfonyl, heteroarylsulfonyl,  $\text{C}_1\text{-C}_6$  alkylsulfonyl and  $\text{C}_6\text{-C}_{10}$  arylsulfonyl, where any alkyl, alkenyl or alkynyl may

optionally be substituted with 1-3 groups selected from OH, halo(F, Cl, Br, I), nitro, amino and aminocarbonyl and the substituents on any aryl, heteroaryl or het are 1-2 hydroxy, halo(F, Cl, Br, I), CF<sub>3</sub>, C<sub>1</sub>-C<sub>6</sub> alkyl, C<sub>1</sub>-C<sub>6</sub> alkoxy, nitro and amino;

R<sup>n</sup> and R<sup>n'</sup> taken together with the common nitrogen to which they are

5 attached may form an optionally substituted heterocycle selected from morpholinyl, piperazinyl, thiamorpholinyl, pyrrolidinyl, imidazolidinyl, indolinyl, isoindolinyl, 1,2,3,4-tetrahydro-quinolinyl, 1,2,3,4-tetrahydro-isoquinolinyl, thiazolidinyl and azabicyclononyl, where the substituents are 1-3 hydroxy, halo(F, Cl, Br, I), CF<sub>3</sub>, C<sub>1</sub>-C<sub>6</sub> alkyl, C<sub>1</sub>-C<sub>6</sub> alkoxy, nitro and amino;

10 R<sup>s</sup> is a substituted or unsubstituted group selected from

C<sub>1</sub>-C<sub>8</sub> alkyl, C<sub>2</sub>-C<sub>8</sub> alkenyl, C<sub>2</sub>-C<sub>8</sub> alkynyl, C<sub>3</sub>-C<sub>8</sub> cycloalkyl, C<sub>3</sub>-C<sub>6</sub> cycloalkenyl, C<sub>0</sub>-C<sub>6</sub> alkyl-phenyl, phenyl-C<sub>0</sub>-C<sub>6</sub> alkyl, C<sub>0</sub>-C<sub>6</sub> alkyl-het and het-C<sub>0</sub>-C<sub>6</sub> alkyl, where the substituents are 1-3 hydroxy, halo(F, Cl, Br, I), CF<sub>3</sub>, C<sub>1</sub>-C<sub>6</sub> alkyl, C<sub>1</sub>-C<sub>6</sub> alkoxy, nitro and amino;

T is U-W; and

15 pharmaceutically acceptable salts thereof.

5) The method of Claim 4 wherein

Y<sup>2</sup>, Y<sup>3</sup> and Y<sup>4</sup> are selected from CH and CR<sup>d</sup>;

Z<sup>1</sup> is selected from NR<sup>n</sup>, O and S;

20 n is 0-3;

R<sup>1</sup>, R<sup>2</sup> and R<sup>3</sup> each are independently R<sup>a</sup>;

R<sup>a</sup> is R<sup>a'</sup> or R<sup>a''</sup> substituted with 1-3 R<sup>a'</sup>; where

R<sup>a'</sup> is selected from the group

25 hydrogen, halo(F, Cl, Br, I), cyano, carboxy, carboxy, amino, amino, aminocarbonyl, carboxamido, carbamoyl, carbamoyloxy, formyl, formyloxy, azido, nitro, imidazoyle, ureido, thioureido, thiocyanato, hydroxy, C<sub>1</sub>-C<sub>6</sub> alkoxy, mercapto, sulfonamido, phenoxy, phenyl, benzamido, morpholino, morpholinyl, piperazinyl, piperidinyl, pyrrolinyl, imidazolyl and indolyl;

R<sup>a''</sup> is hydrogen or a substituted or unsubstituted group selected from

30 C<sub>0</sub>-C<sub>10</sub> alkyl-het, C<sub>1</sub>-C<sub>10</sub> alkyl, C<sub>2</sub>-C<sub>10</sub> alkenyl, C<sub>2</sub>-C<sub>10</sub> alkynyl, C<sub>3</sub>-C<sub>11</sub> cycloalkyl, C<sub>3</sub>-C<sub>10</sub> cycloalkenyl-C<sub>0</sub>-C<sub>6</sub> alkyl, C<sub>1</sub>-C<sub>6</sub> alkyl-C<sub>6</sub>-C<sub>12</sub> aryl and C<sub>6</sub>-C<sub>10</sub> aryl-C<sub>1</sub>-C<sub>6</sub> alkyl, where the substituents are 1-3 hydroxy, halo(F, Cl, Br, I), CF<sub>3</sub>, C<sub>1</sub>-C<sub>6</sub> alkyl, C<sub>1</sub>-C<sub>6</sub> alkoxy, nitro and



amino;

$R^d$  is selected from the group:

OH,  $OCF_3$ ,  $OR^{a''}$ ,  $SR^m$ , halo(F, Cl, Br, I), CN,  $NO_2$ ,  $CF_3$ ,  $C_0-C_6$  alkyl- $C(=O)-R^a$ ,  $C_1-C_8$  alkyl,  $C_1-C_8$  alkoxy,  $C_2-C_8$  alkenyl,  $C_2-C_8$  alkynyl,  $C_3-C_6$  cycloalkyl, phenyl- $C_1-C_6$  alkyl,  $C_1-C_6$  alkyloxycarbonyl,  $-O-C_6-C_{12}$  aryl and  $-SO_2-C_6-C_{12}$  aryl, where any alkyl, alkenyl or alkynyl may optionally be substituted with 1-3 groups selected from OH, halo(F, Cl, Br, I), nitro, amino and aminocarbonyl and the substituents on any aryl or het are 1-2 hydroxy, halo(F, Cl, Br, I),  $CF_3$ ,  $C_1-C_6$  alkyl,  $C_1-C_6$  alkoxy, nitro and amino;

$R^m$  is selected from

$S-C_1-C_6$  alkyl,  $C(=O)-C_1-C_6$  alkyl,  $C(=O)-NH_2$ ,  $C_1-C_6$  alkyl, halo(F, Cl, Br, I)- $C_1-C_6$  alkyl, benzyl and phenyl;

$R^n$  is selected from the group

$R^{a''}$ ,  $NH-C(=O)-O-R^{a''}$ ,  $NH-C(=O)-R^{a''}$ ,  $NH-C(=O)-NHR^{a''}$ ,  $NH-SO_2-R^S$ ,  $NH-SO_2-NH-C(=O)-R^{a''}$ ,  $NH-C(=O)-NH-SO_2-R^S$ ,  $C(=O)-O-R^{a''}$ ,  $C(=O)R^{a''}$ ,  $C(=O)-NHR^{a''}$ ,  $C(=O)-NH-C(=O)-O-R^{a''}$ ,  $C(=O)-NH-C(=O)-R^{a''}$ ,  $C(=O)-NH-SO_2-R^S$ ,  $C(=O)-NH-SO_2-NHR^S$ ,  $SO_2-R^S$ ,  $SO_2-O-R^S$ ,  $SO_2-N(R)_2$ ,  $SO_2-NH-C(=O)-O-R^{a''}$ ,  $SO_2-NH-C(=O)-O-R^{a''}$  and  $SO_2-NH-C(=O)-R^{a''}$ ;

$R^{n'}$  is selected from hydrogen, hydroxy and substituted or unsubstituted

$C_1-C_{11}$  alkyl,  $C_1-C_{11}$  alkoxy,  $C_2-C_{10}$  alkenyl,  $C_2-C_{10}$  alkynyl,  $C_3-C_{11}$  cycloalkyl,  $C_3-C_{10}$  cycloalkenyl,  $C_1-C_6$  alkyl- $C_6-C_{12}$  aryl,  $C_6-C_{10}$  aryl- $C_1-C_6$  alkyl,  $C_6-C_{10}$  aryl- $C_0-C_6$  alkyloxy,  $C_1-C_6$  alkyl-het, het- $C_1-C_6$  alkyl,  $C_6-C_{12}$  aryl, het,  $C_1-C_6$  alkylcarbonyl,  $C_1-C_8$  alkoxy,  $C_3-C_8$  cycloalkylcarbonyl,  $C_3-C_8$  cycloalkoxy,  $C_6-C_{11}$  aryloxy,  $C_7-C_{11}$  arylalkoxy, heteroarylalkoxy, heteroarylalkylcarbonyl, heteroarylcarbonyl, heteroarylalkylsulfonyl, heteroarylsulfonyl,  $C_1-C_6$  alkylsulfonyl and  $C_6-C_{10}$  arylsulfonyl, where any alkyl, alkenyl or alkynyl may optionally be substituted with 1-3 groups selected from OH, halo(F, Cl, Br, I), nitro, amino and aminocarbonyl and the substituents on any aryl, heteroaryl or het are 1-2 hydroxy, halo(F, Cl, Br, I),  $CF_3$ ,  $C_1-C_6$  alkyl,  $C_1-C_6$  alkoxy, nitro and amino;

$R^n$  and  $R^{n'}$  taken together with the common nitrogen to which they are

attached may form an optionally substituted heterocycle selected from morpholinyl, piperazinyl, thiomorpholinyl, pyrrolidinyl, imidazolidinyl, indolinyl, isoindolinyl, 1,2,3,4-tetrahydro-quinolinyl, 1,2,3,4-tetrahydro-isoquinolinyl, thiazolidinyl and azabicyclononyl, where the substituents are 1-3 hydroxy, halo(F, Cl, Br, I),  $CF_3$ ,  $C_1-C_6$  alkyl,  $C_1-C_6$  alkoxy, nitro and amino;

$R^S$  is a substituted or unsubstituted group selected from

$C_1-C_8$  alkyl,  $C_2-C_8$  alkenyl,  $C_2-C_8$  alkynyl,  $C_3-C_8$  cycloalkyl,  $C_3-C_6$  cycloalkenyl,  $C_0-C_6$  alkyl-phenyl, phenyl- $C_0-C_6$  alkyl,  $C_0-C_6$  alkyl-het and het- $C_0-C_6$  alkyl, where the substituents are 1-3 hydroxy, halo(F, Cl, Br, I),  $CF_3$ ,  $C_1-C_6$  alkyl,  $C_1-C_6$  alkoxy, nitro and amino; T is U-W, where

U is an optionally substituted bivalent radical selected from the group

$C_1-C_6$  alkyl-Q-,  $C_2-C_6$  alkenyl-Q-, and  $C_2-C_6$  alkynyl-Q-, where the substituents on any alkyl, alkenyl or alkynyl are 1-3  $R^a$ ;

Q is absent or is selected from the group

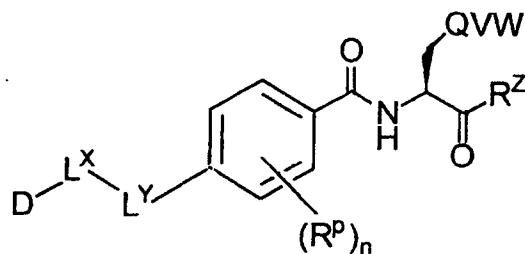
$-SO_2-N(R^n)-$ ,  $-N(R^n)-$ ,  $-N(R^n)-C(=O)-$ ,  $-N(R^n)-C(=O)-O-$ ,  $-N(R^n)-SO_2-$ ,  $-C(=O)-N(R^n)-$ ,  $C(=O)-O-$ ,  $-C(=O)-O-$ ,  $-C(=O)-$  and  $-C(=O)-N(R^n)-$ ;

W is selected from the group

hydrogen, OH,  $O-C_1-C_6$  alkyl, SH,  $SR^m$ ,  $NR^nR^{n'}$ ,  $NH-C(=O)-O-R^{a''}$ ,  $NH-C(=O)-NR^nR^{n'}$ ,  $NH-C(=O)-R^{a''}$ ,  $NH-SO_2-R^S$ ,  $NH-SO_2-NR^nR^{n'}$ ,  $NH-SO_2-NH-C(=O)-R^{a''}$ ,  $NH-C(=O)-NH-SO_2-R^S$ ,  $C(=O)-NH-C(=O)-O-R^{a''}$ ,  $C(=O)-NH-C(=O)-R^{a''}$ ,  $C(=O)-NH-C(=O)-NR^nR^{n'}$ ,  $C(=O)-NH-SO_2-R^S$ ,  $C(=O)-NH-SO_2-NR^nR^{n'}$ ,  $C(=S)-NR^nR^{n'}$ ,  $SO_2-R^S$ ,  $SO_2-O-R^S$ ,  $SO_2-NR^nR^{n'}$ ,  $SO_2-NH-C(=O)-O-R^{a''}$ ,  $SO_2-NH-C(=O)-NR^nR^{n'}$ ,  $SO_2-NH-C(=O)-R^{a''}$ ,  $O-C(=O)-NR^nR^{n'}$ ,  $O-C(=O)-R^{a''}$ ,  $O-C(=O)-NH-C(=O)-R^{a''}$ ,  $O-C(=O)-NH-SO_2-R^S$  and  $O-SO_2-R^S$ ; and

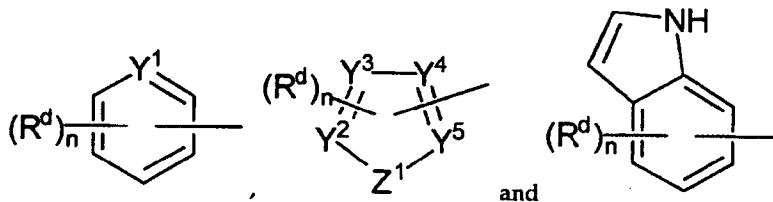
pharmaceutically acceptable salts thereof.

6) A method of treating mammal having an immune disorder mediated through the CD11/CD18 family of adhesion receptors comprising the step of administering a pharmacologically effective amount of a compound represented by the formula:



where

D is selected from the group



5

where

$Y^1$  is selected from the group  $NR^n$ , CH and  $CR^d$ ;

$Y^2$ ,  $Y^3$ ,  $Y^4$  and  $Y^5$  are selected from the group CH and  $CR^d$ ;

$Z^1$  is selected from the group  $NR^n$ , O and S;

n is 0-3;

10  $L^X$  is selected from the group substituted or unsubstituted

$C_2$ - $C_5$  alkylene,

$C_3$ - $C_6$  cycloalkylene,

$C_0$ - $C_3$  alkylene- $NR^n$ -(C=O)- $C_0$ - $C_3$  alkylene,

$C_0$ - $C_3$  alkylene-(C=O)- $NR^n$ - $C_0$ - $C_3$  alkylene,

15  $C_0$ - $C_3$  alkylene-O- $C_0$ - $C_3$  alkylene,

$C_0$ - $C_3$  alkylene- $NR^n$ - $C_0$ - $C_3$  alkylene,

$C_0$ - $C_3$  alkylene-(C=O)- $C_0$ - $C_3$  alkylene,

$C_0$ - $C_3$  alkylene-S(O)<sub>0-2</sub>- $C_0$ - $C_3$  alkylene,

$C_0$ - $C_3$  alkylene- $NR^n$ -SO<sub>2</sub>- $C_0$ - $C_3$  alkylene,

20  $C_0$ - $C_3$  alkylene-SO<sub>2</sub>- $NR^n$ - $C_0$ - $C_3$  alkylene,

$C_0$ - $C_3$  alkylene-CR<sup>1</sup>=CR<sup>2</sup>- $C_0$ - $C_3$  alkylene,

$C_0-C_3$ alkylene- $C\equiv C-C_0-C_3$ alkylene and

$C_0-C_3$ alkylene-het- $C_0-C_3$ alkylene

where the substituents are selected from the group one to three  $R^1$ ,  $R^2$  and  $R^3$ ;

$L^Y$  is selected from the group substituted or unsubstituted

- 5  $C_0-C_2$ alkylene,
- $C_0-C_2$ alkylene- $NR^n-(C=O)-C_0-C_2$ alkylene,
- $C_0-C_2$ alkylene- $(C=O)-NR^n-C_0-C_2$ alkylene,
- $C_0-C_2$ alkylene- $O-C_0-C_2$ alkylene,
- $C_0-C_2$ alkylene- $NR^n-C_0-C_2$ alkylene,
- 10  $C_0-C_2$ alkylene- $(C=O)-C_0-C_2$ alkylene,
- $C_0-C_3$ alkylene- $S(O)_{0-2}-C_0-C_3$ alkylene,
- $C_0-C_3$ alkylene- $SO_2-NR^n-C_0-C_3$ alkylene and
- $C_0-C_2$ alkylene-aryl- $C_0-C_2$ alkylene

where the substituents are selected from the group one to three  $R^1$ ,  $R^2$  and  $R^3$ ;

- 15  $R^1$ ,  $R^2$  and  $R^3$  are selected from the group

- hydrogen,
- $C_1-C_8$ alkyl-hydroxy,
- halo(F, Cl, Br, I),
- halo(F, Cl, Br, I)- $C_1-C_8$ alkyl,
- 20 cyano,
- isocyanate,
- carboxy,
- carboxy- $C_1-C_6$ alkyl,
- amino,
- 25 amino- $C_1-C_8$ alkyl,
- amino-di( $C_1-C_8$ alkyl),
- aminocarbonyl,
- carboxamido,
- carbamoyl,

carbamoyloxy,  
formyl,  
formyloxy,  
nitro,  
5 imidazolyl,  
ureido,  
thioureido,  
thiocyanato,  
hydroxy,  
10 C<sub>1</sub>-C<sub>6</sub>alkoxy,  
mercapto,  
sulfonamido,  
phenoxy,  
phenyl, and  
15 benzamido;  
R<sup>a</sup> is selected from the group  
hydrogen,  
halo(F, Cl, Br, I),  
cyano,  
20 isocyanate,  
carboxy,  
carboxy-C<sub>1</sub>-C<sub>6</sub>alkyl,  
amino,  
amino-C<sub>1</sub>-C<sub>8</sub>alkyl,  
25 aminocarbonyl,  
carboxamido,  
carbamoyl,  
carbamoyloxy,  
formyl,  
30 formyloxy,  
azido,  
nitro,  
imidazolyl,  
ureido,  
35 thioureido,  
thiocyanato,

hydroxy,  
 $C_1-C_6$ alkoxy,  
 mercapto,  
 sulfonamido,  
 5  $C_1-C_6$ alkylsulfonyl,  
 het,  
 phenoxy,  
 phenyl,  
 benzamido,  
 10 tosyl,  
 morpholino,  
 morpholinyl,  
 piperazinyl,  
 piperidinyl,  
 15 pyrrolinyl.  
 imidazolyl and  
 indolyl;

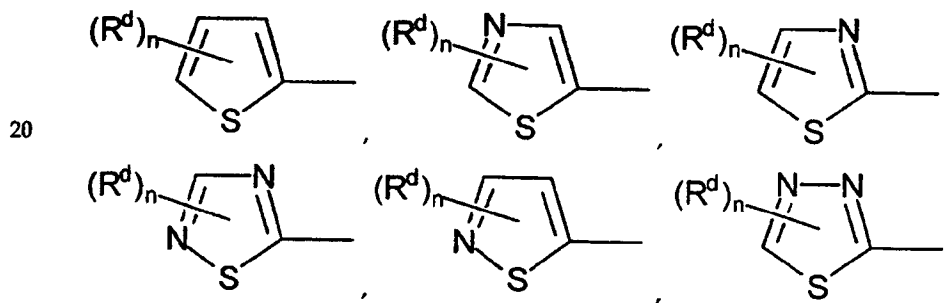
$R^C$  is selected from hydrogen and substituted or unsubstituted

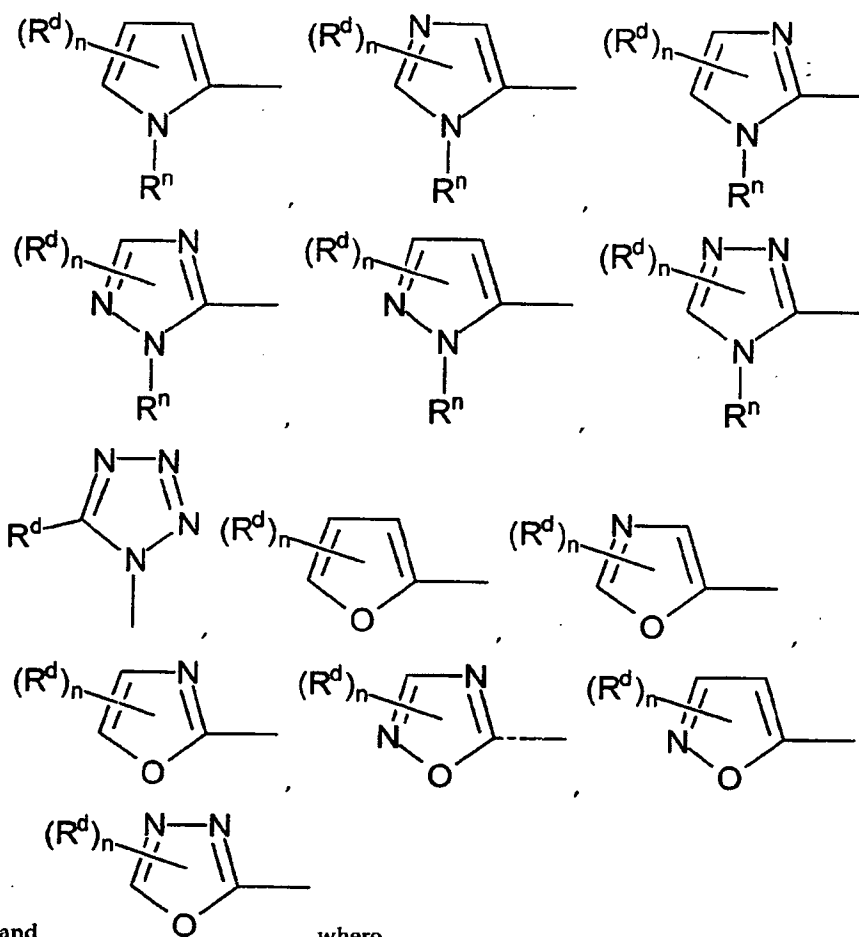
$C_1-C_{10}$ alkyl,  
 20  $C_2-C_{10}$ alkenyl,  
 $C_2-C_{10}$ alkynyl,  
 $C_3-C_{11}$ cycloalkyl,  
 $C_3-C_{10}$ cycloalkenyl,  
 $C_1-C_6$ alkyl- $C_6-C_{12}$ aryl,  
 25  $C_6-C_{10}$ aryl- $C_1-C_6$ alkyl,  
 $C_1-C_6$ alkyl-het,  
 het- $C_1-C_6$ alkyl,  
 $C_6-C_{12}$ aryl,  
 $C_1-C_{10}$ alkyl-O-,  
 30  $C_2-C_{10}$ alkenyl-O-,  
 $C_2-C_{10}$ alkynyl-O-,  
 $C_3-C_{11}$ cycloalkyl-O-,

- $C_3-C_{10}$  cycloalkenyl-O-,  
 $C_1-C_6$  alkyl- $C_6-C_{12}$  aryl-O-,  
 $C_6-C_{10}$  aryl- $C_1-C_6$  alkyl-O-,  
 $C_1-C_6$  alkyl-het-O-,  
 5    het- $C_0-C_6$  alkyl-O-,  
 $C_6-C_{12}$  aryl-O-  
 $C_1-C_{10}$  alkyl-NR<sup>n</sup>-,  
 $C_2-C_{10}$  alkenyl-NR<sup>n</sup>-,  
 $C_2-C_{10}$  alkynyl-NR<sup>n</sup>-,  
 10     $C_3-C_{11}$  cycloalkyl-NR<sup>n</sup>-,  
 $C_3-C_{10}$  cycloalkenyl-NR<sup>n</sup>-,  
 $C_1-C_6$  alkyl- $C_6-C_{12}$  aryl-NR<sup>n</sup>-,  
 $C_6-C_{10}$  aryl- $C_1-C_6$  alkyl-NR<sup>n</sup>-,  
 $C_1-C_6$  alkyl-het-NR<sup>n</sup>-,  
 15    het- $C_0-C_6$  alkyl-NR<sup>n</sup>-,  
 $C_6-C_{12}$  aryl-NR<sup>n</sup>- and

het, where the substituents on any alkyl, alkenyl or alkynyl are 1-3 R<sup>a</sup> and the substituents on any aryl or het are 1-3 R<sup>d</sup>;

het is selected from the group



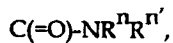
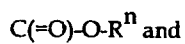
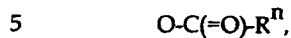
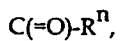
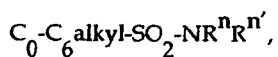
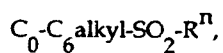
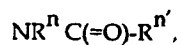


5 and where

$R^p$  and  $R^d$  are independently selected from the group

- OH,
- CN,
- NO<sub>2</sub>,
- 10 halo(F, Cl, Br, I),
- OR<sup>n</sup>,
- SR<sup>n</sup>,
- SOR<sup>n</sup>,
- CF<sub>3</sub>,
- 15 R<sup>c</sup>,
- NR<sup>n</sup>R<sup>n'</sup>,
- NR<sup>n</sup>C(=O)-O-R<sup>n'</sup>,





$\text{R}^d$  is a chemical bond when het is a divalent linking group;

$\text{R}^n$  and  $\text{R}^{n'}$  are independently selected from the group

hydrogen,

hydroxy,

$\text{C}_1\text{-C}_6$  alkyl,

halo(F, Cl, Br, I)- $\text{C}_1\text{-C}_6$  alkyl,

$\text{C}_1\text{-C}_6$  alkyl-het,

het- $\text{C}_1\text{-C}_6$  alkyl,

$\text{C}_6\text{-C}_{12}$  aryl, and

het;

$\text{R}^Z$  is a substituted or unsubstituted group selected from

hydroxy,

$\text{C}_1\text{-C}_{11}$  alkoxy,

$\text{C}_3\text{-C}_{12}$  cycloalkoxy,

$\text{C}_8\text{-C}_{12}$  aralkoxy,

$\text{C}_8\text{-C}_{12}$  arcycloalkoxy,

$\text{C}_6\text{-C}_{10}$  aryloxy,

$\text{C}_3\text{-C}_{10}$  alkylcarbonyloxyalkyloxy,

$\text{C}_3\text{-C}_{10}$  alkoxycarbonyloxyalkyloxy,

$\text{C}_3\text{-C}_{10}$  alkoxycarbonylalkyloxy,

$\text{C}_5\text{-C}_{10}$  cycloalkylcarbonyloxyalkyloxy,

$C_5-C_{10}$  cycloalkoxycarbonyloxyalkyloxy,

$C_5-C_{10}$  cycloalkoxycarbonylalkyloxy,

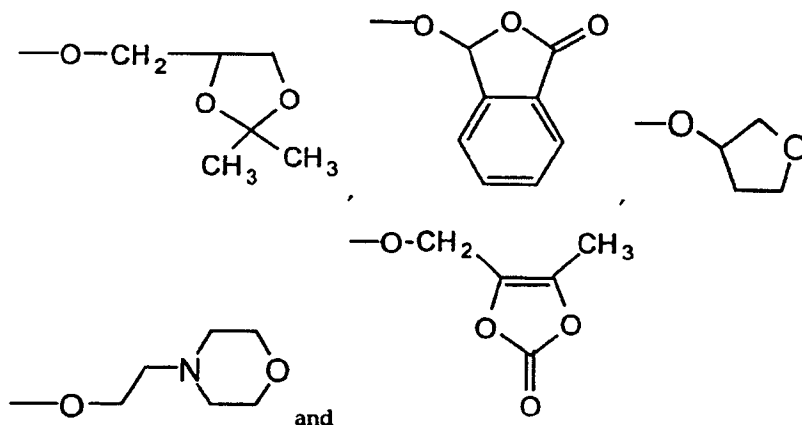
$C_8-C_{12}$  aryloxy carbonylalkyloxy,

$C_8-C_{12}$  aryloxy carbonyloxyalkyloxy,

5  $C_8-C_{12}$  aryl carbonyloxyalkyloxy,

$C_5-C_{10}$  alkoxyalkyl carbonyloxyalkyloxy,

$(R^n)(R^{n'})N(C_1-C_{10} \text{ alkoxy})-$ ,



10 where the substituents on any alkyl, alkenyl or alkynyl are 1-3  $R^a$  and the substituents on any aryl or het are 1-3  $R^d$ ;

Q is absent or is  $C_0-C_3$  alkyl substituted with a group selected from

$-N(R^n)-$ ,

$-N(R^n)-C(=O)-$ ,

15  $-N(R^n)-C(=O)-O-$ ,

$-N(R^n)-C(=O)-N(R^n)-$ ,

$-N(R^n)-SO_2-$ ,

$-C(=O)-$ ,

$-O-C(=O)-N(R^n)-$ ,

20  $-C(=O)-N(R^n)-$ ,

V is absent or is an optionally substituted bivalent group selected from

$C_1-C_{11}$  alkylene,

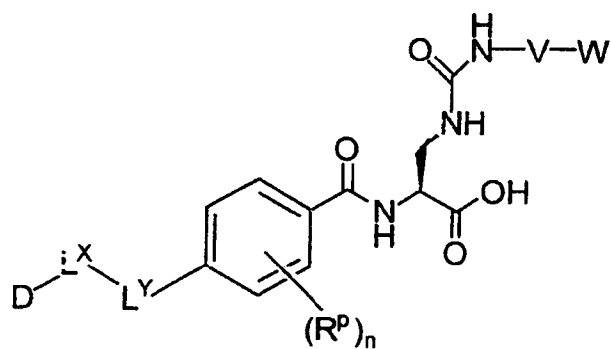
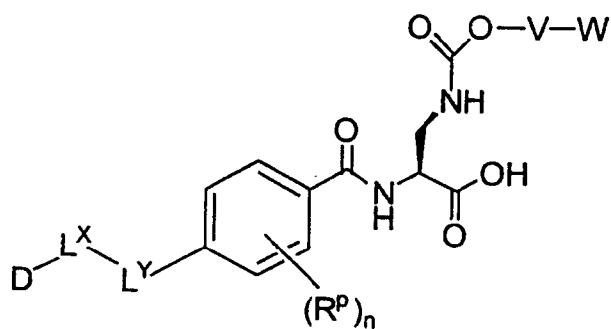
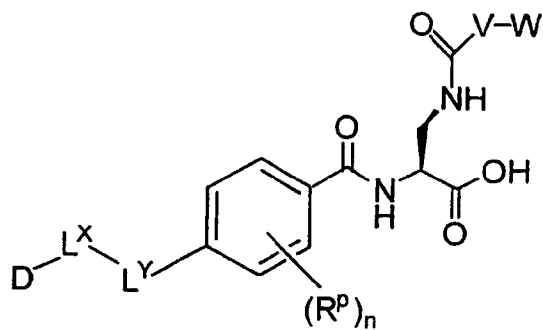
- $C_0-C_3$ alkylene-O- $C_0-C_3$ alkylene,  
 $C_2-C_6$ alkenylene,  
 $C_0-C_2$ alkylene-O- $C_2-C_4$ alkenylene,  
 $C_3-C_8$ cycloalkylene,  
5  $C_6-C_{10}$ aryl- $C_0-C_6$ alkylene,  
 $C_0-C_6$ alkyl- $C_6-C_{10}$ arylene and  
 $C_0-C_6$ alkyl-het;

where the substituents on any alkyl are 1-3  $R^a$  and the substituents on any aryl or het are 1-3  $R^d$ ;

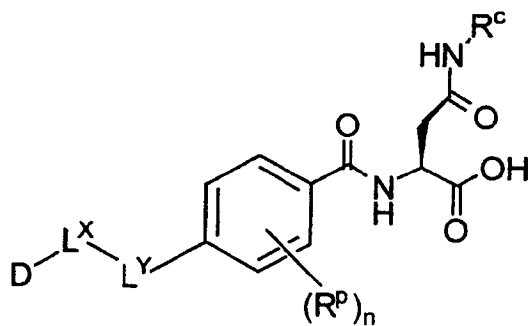
- 10 W is a  $C_0-C_3$ -alkyl substituted with a group selected from

- $R^a$ ,  
 $NH-C(=O)-NR^nR^{n'}$ ,  
 $NH-C(=O)-R^c$ ,  
 $C(=O)-R^c$ ,  
15  $C(=O)-NH-C(=O)-R^c$ ,  
 $C(=O)-NH-C(=O)-NR^nR^{n'}$ ,  
 $C(=O)-NH-SO_2-R^c$ ,  
 $C(=O)-NH-SO_2-NR^nR^{n'}$ ,  
 $C(=O)NR^nR^{n'}$ ,  
20  $NH-C(=O)-R^c$  and  
 $R^c$  and pharmaceutically acceptable salts thereof.

7) The method of Claim 6 wherein the compound selected from the group



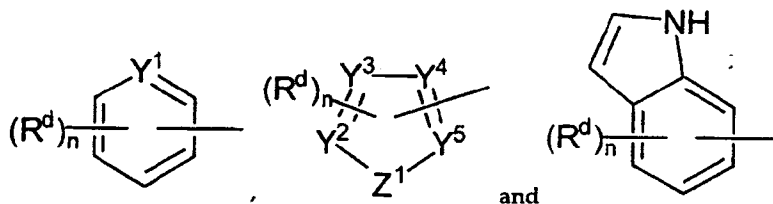
and



5

where

D is selected from the group



where  $Y^1, Y^2, Y^3, Y^4$  and  $Y^5$  are selected from the group CH and  $CR^d$ ;

$Z^1$  is selected from the group  $NR^n$ , O and S;

$n$  is 0-3;

- 5  $L^X$  is selected from the group substituted or unsubstituted

$C_2-C_5$  alkylene,

$C_3-C_6$  cycloalkylene,

$C_0-C_3$  alkylene- $NR^n$ -(C=O)- $C_0-C_3$  alkylene,

$C_0-C_3$  alkylene-(C=O)- $NR^n$ - $C_0-C_3$  alkylene,

- 10  $C_0-C_3$  alkylene-O- $C_0-C_3$  alkylene,

$C_0-C_3$  alkylene- $NR^n$ - $C_0-C_3$  alkylene,

$C_0-C_3$  alkylene-(C=O)- $C_0-C_3$  alkylene,

$C_0-C_3$  alkylene-S(O)<sub>0-2</sub>- $C_0-C_3$  alkylene,

$C_0-C_3$  alkylene- $NR^n$ -SO<sub>2</sub>- $C_0-C_3$  alkylene,

- 15  $C_0-C_3$  alkylene-SO<sub>2</sub>- $NR^n$ - $C_0-C_3$  alkylene,

$C_0-C_3$  alkylene-CR<sup>1</sup>=CR<sup>2</sup>- $C_0-C_3$  alkylene,

$C_0-C_3$  alkylene-C≡C- $C_0-C_3$  alkylene and

$C_0-C_3$  alkylene-het- $C_0-C_3$  alkylene

where the substituents are selected from the group one to three  $R^1, R^2$  and  $R^3$ ;

- 20  $L^Y$  is selected from the group substituted or unsubstituted

$C_0-C_2$  alkylene,

$C_0-C_2$  alkylene- $NR^n$ -(C=O)- $C_0-C_2$  alkylene,

$C_0-C_2$  alkylene-(C=O)- $NR^n$ - $C_0-C_2$  alkylene,

- $C_0-C_2$ alkylene-O- $C_0-C_2$ alkylene,  
 $C_0-C_2$ alkylene-NR<sup>n</sup>- $C_0-C_2$ alkylene,  
 $C_0-C_2$ alkylene-(C=O)- $C_0-C_2$ alkylene,  
 $C_0-C_3$ alkylene-S(O)<sub>0-2</sub>- $C_0-C_3$ alkylene,  
5  $C_0-C_3$ alkylene-SO<sub>2</sub>-NR<sup>n</sup>- $C_0-C_3$ alkylene and  
 $C_0-C_2$ alkylene-aryl- $C_0-C_2$ alkylene

where the substituents are selected from the group one to three R<sup>1</sup>, R<sup>2</sup> and R<sup>3</sup>;

R<sup>1</sup>, R<sup>2</sup> and R<sup>3</sup> are selected from the group

- hydrogen,  
 10  $C_1-C_8$ alkyl-hydroxy,  
 halo(F, Cl, Br, I),  
 halo(F, Cl, Br, I)- $C_1-C_8$ alkyl,  
 cyano,  
 isocyanate,  
 15 carboxy,  
 carboxy- $C_1-C_{11}$ alkyl,  
 amino,  
 amino- $C_1-C_8$ alkyl,  
 amino-di( $C_1-C_8$ alkyl),  
 20 aminocarbonyl,  
 carboxamido,  
 carbamoyl,  
 carbamoyloxy,  
 formyl,  
 25 formyloxy,  
 azido,  
 nitro,  
 imidazolyl,  
 ureido,  
 30 thioureido,  
 thiocyanato,  
 hydroxy,

$C_1-C_6$  alkoxy,  
 mercapto,  
 sulfonamido,  
 phenoxy,  
 5      phenyl, and  
 benzamido;

$R^a$  is selected from the group

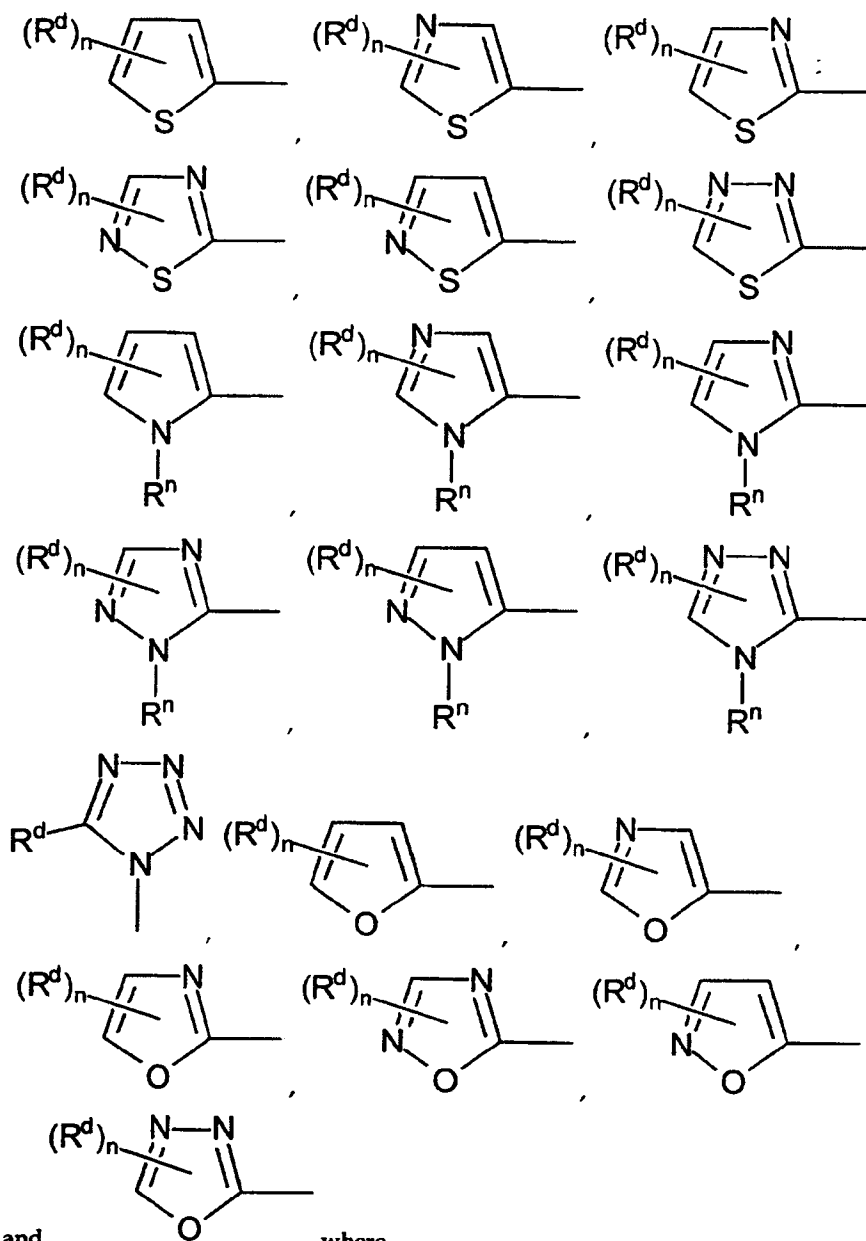
hydrogen,  
 halo(F, Cl, Br, I),  
 10      carboxy,  
 amino,  
 amino- $C_1-C_8$  alkyl,  
 aminocarbonyl,  
 carboxamido,  
 15      carbamoyl,  
 carbamoyloxy,  
 formyl,  
 formyloxy,  
 imidazolyl,  
 20      ureido,  
 hydroxy,  
 $C_1-C_6$  alkoxy,  
 sulfonamido,  
 het,  
 25      phenoxy and  
 phenyl,

$R^c$  is selected from hydrogen and substituted or unsubstituted

$C_1-C_{10}$  alkyl,  
 $C_2-C_{10}$  alkenyl,  
 30       $C_2-C_{10}$  alkynyl,  
 $C_3-C_{11}$  cycloalkyl,  
 $C_3-C_{10}$  cycloalkenyl,  
 $C_1-C_6$  alkyl- $C_6-C_{12}$  aryl,  
 $C_6-C_{10}$  aryl- $C_1-C_6$  alkyl,

- $C_1-C_6$  alkyl-het,  
 het- $C_1-C_6$  alkyl,  
 $C_6-C_{12}$  aryl,  
 $C_1-C_{10}$  alkyl-O-,  
 5  $C_2-C_{10}$  alkenyl-O-,  
 $C_2-C_{10}$  alkynyl-O-,  
 $C_3-C_{11}$  cycloalkyl-O-,  
 $C_3-C_{10}$  cycloalkenyl-O-,  
 $C_1-C_6$  alkyl- $C_6-C_{12}$  aryl-O-,  
 10  $C_6-C_{10}$  aryl- $C_1-C_6$  alkyl-O-,  
 $C_1-C_6$  alkyl-het-O-,  
 het- $C_0-C_6$  alkyl-O-,  
 $C_6-C_{12}$  aryl-O-  
 $C_1-C_{10}$  alkyl-NR<sup>n</sup>-,  
 15  $C_2-C_{10}$  alkenyl-NR<sup>n</sup>-,  
 $C_2-C_{10}$  alkynyl-NR<sup>n</sup>-,  
 $C_3-C_{11}$  cycloalkyl-NR<sup>n</sup>-,  
 $C_3-C_{10}$  cycloalkenyl-NR<sup>n</sup>-,  
 $C_1-C_6$  alkyl- $C_6-C_{12}$  aryl-NR<sup>n</sup>-,  
 20  $C_6-C_{10}$  aryl- $C_1-C_6$  alkyl-NR<sup>n</sup>-,  
 $C_1-C_6$  alkyl-het-NR<sup>n</sup>-,  
 het- $C_0-C_6$  alkyl-NR<sup>n</sup>-,  
 $C_6-C_{12}$  aryl-NR<sup>n</sup>- and het, where the substituents on any alkyl, alkenyl or alkynyl are 1-3 R<sup>a</sup>  
 and the substituents on any aryl or het are 1-3 R<sup>d</sup>;  
 25 het is selected from the group





$R^p$  and  $R^d$  are independently selected from the group

- 10
- OH,
  - CN,
  - $\text{NO}_2$ ,
  - halo(F, Cl, Br, I),
  - $\text{OR}^n$ ,
  - $\text{SR}^n$ ,

- $\text{SOR}^n$ ,  
 $\text{CF}_3$ ,  
 $\text{R}^c$ ,  
 $\text{NR}^n\text{R}^{n'}$ ,  
5  $\text{NR}^n\text{C}(=\text{O})\text{-O-R}^{n'}$ ,  
 $\text{NR}^n\text{C}(=\text{O})\text{-R}^{n'}$ ,  
 $\text{C}_0\text{-C}_6\text{alkyl-SO}_2\text{-R}^n$ ,  
 $\text{C}_0\text{-C}_6\text{alkyl-SO}_2\text{-NR}^n\text{R}^{n'}$ ,  
 $\text{C}(=\text{O})\text{-R}^n$ ,  
10  $\text{O-C}(=\text{O})\text{-R}^n$ ,  
 $\text{C}(=\text{O})\text{-O-R}^n$  and  
 $\text{C}(=\text{O})\text{-NR}^n\text{R}^{n'}$ ,

$\text{R}^d$  is a chemical bond when het is a divalent linking group;

$\text{R}^n$  and  $\text{R}^{n'}$  are independently selected from the group

- 15 hydrogen,  
hydroxy,  
 $\text{C}_1\text{-C}_6\text{alkyl}$  and  
halo(F, Cl, Br, I)- $\text{C}_1\text{-C}_6\text{alkyl}$ ;

V is absent or is an optionally substituted bivalent group selected from

- 20  $\text{C}_1\text{-C}_6\text{alkylene}$ ,  
 $\text{C}_0\text{-C}_3\text{alkylene-O-C}_0\text{-C}_3\text{alkylene}$ ,  
 $\text{C}_2\text{-C}_6\text{alkenylene}$ ,  
 $\text{C}_0\text{-C}_2\text{alkylene-O-C}_2\text{-C}_4\text{alkenylene}$ ,  
 $\text{C}_3\text{-C}_8\text{cycloalkylene}$ ,  
25  $\text{C}_0\text{-C}_6\text{alkyl-C}_6\text{-C}_{10}\text{arylene}$  and  
 $\text{C}_0\text{-C}_6\text{alky-het}$ ;

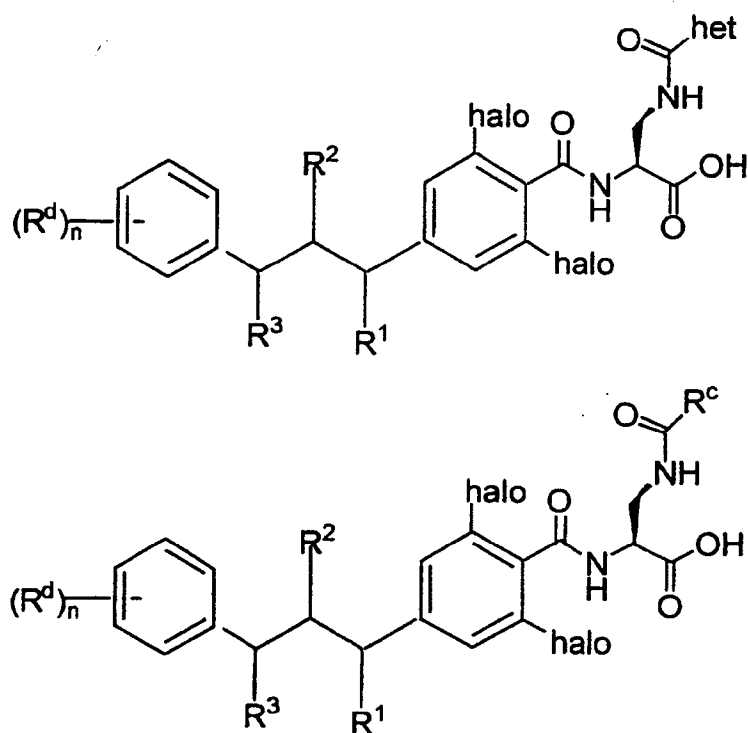
where the substituents on any alkyl are 1-3  $\text{R}^a$  and the substituents on any aryl or het are 1-3  $\text{R}^d$ ;

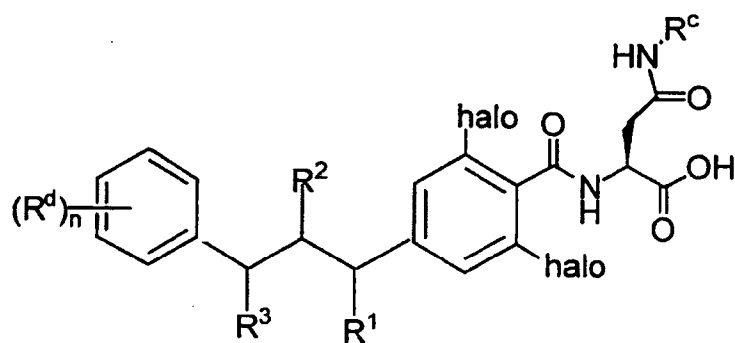
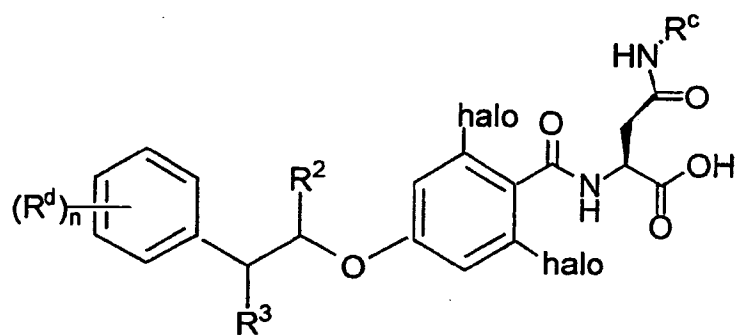
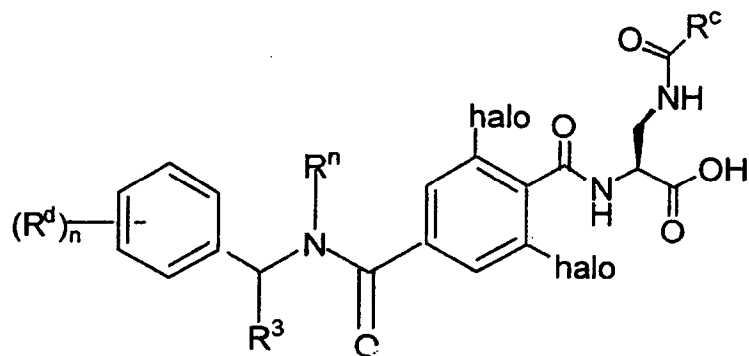
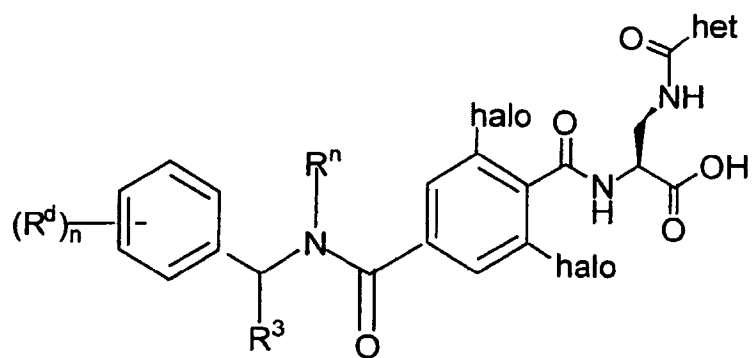
W is selected from the group

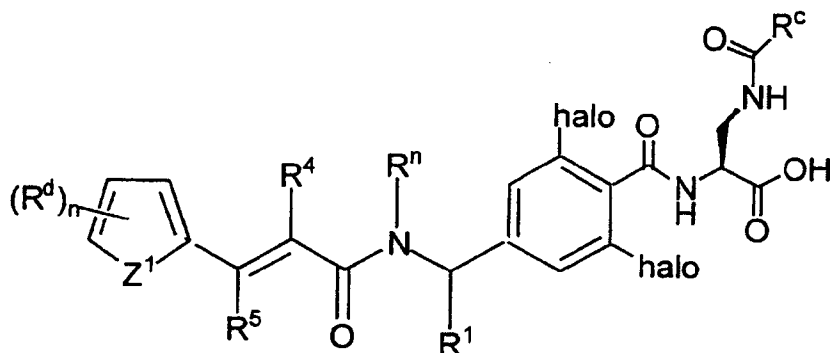
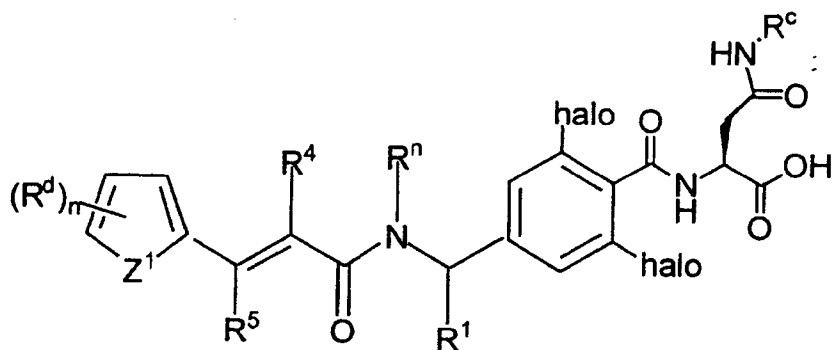
hydrogen,

- $\text{NH-C(=O)-NR}^n\text{R}^{n'}$ ,  
 $\text{NH-C(=O)-R}^c$ ,  
 $\text{C(=O)-NH-C(=O)-R}^c$ ,  
 $\text{C(=O)-NH-C(=O)-NR}^n\text{R}^{n'}$ ,  
5  $\text{C(=O)-NH-SO}_2\text{-R}^c$ ,  
 $\text{C(=O)-NH-SO}_2\text{-NR}^n\text{R}^{n'}$ ,  
 $\text{C(=O)NR}^n\text{R}^{n'}$ ,  
 $\text{NH-C(=O)-R}^c$  and  
 $\text{R}^d$ ; and  
10 pharmaceutically acceptable salts thereof.

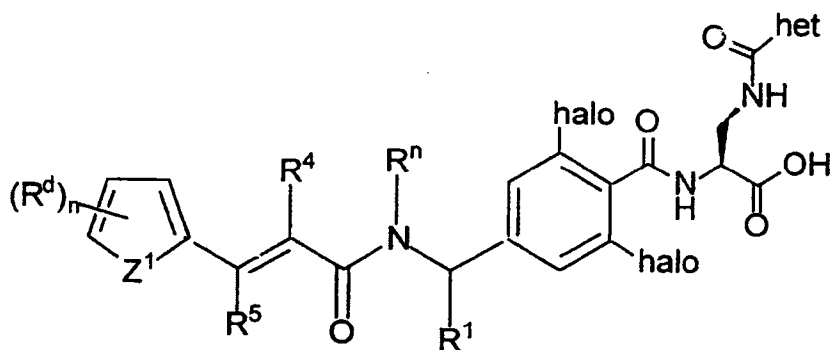
8) The method of Claim 6 wherein the compound is selected from the group







and



5 where  
 $R^1, R^2, R^3, R^4$ , and  $R^5$  are selected from the group

hydrogen,

$C_1-C_8$  alkyl,

$C_1-C_8$  alkyl-hydroxy,

10 halo(F, Cl, Br, I),

halo(F, Cl, Br, I)- $C_1-C_8$  alkyl,

amino,

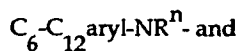
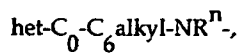
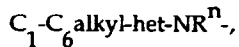
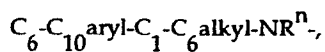
amino- $C_1-C_8$  alkyl,

aminocarbonyl-C<sub>0</sub>-C<sub>6</sub> alkyl,  
 amino-di(C<sub>1</sub>-C<sub>8</sub> alkyl),  
 carboxamido,  
 carbamoyl,  
 5 carbamoyloxy,  
 formyl,  
 formyloxy,  
 ureido,  
 hydroxy,  
 10 C<sub>1</sub>-C<sub>6</sub> alkoxy,  
 sulfonamido,  
 phenyl and  
 phenoxy,

R<sup>a</sup> is selected from the group

15 hydrogen,  
 halo(F, Cl, Br, I),  
 cyano,  
 isocyanate,  
 carboxy,  
 20 amino,  
 amino-C<sub>1</sub>-C<sub>8</sub> alkyl,  
 aminocarbonyl,  
 carboxamido,  
 carbamoyl,  
 25 carbamoyloxy,  
 formyl,  
 formyloxy,  
 imidazolyl,  
 ureido,  
 30 hydroxy,  
 C<sub>1</sub>-C<sub>6</sub> alkoxy,  
 sulfonamido,  
 phenoxy and  
 phenyl,  
 35 R<sup>c</sup> is selected from hydrogen and substituted or unsubstituted

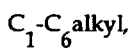
- $C_1-C_{10}$  alkyl,  
 $C_2-C_{10}$  alkenyl,  
 $C_2-C_{10}$  alkynyl,  
 $C_3-C_{11}$  cycloalkyl,  
5  $C_3-C_{10}$  cycloalkenyl,  
 $C_1-C_6$  alkyl- $C_6-C_{12}$  aryl,  
 $C_6-C_{10}$  aryl- $C_1-C_6$  alkyl,  
 $C_1-C_6$  alkyl-het,  
het- $C_1-C_6$  alkyl,  
10  $C_6-C_{12}$  aryl,  
 $C_1-C_{10}$  alkyl-O-,  
 $C_2-C_{10}$  alkenyl-O-,  
 $C_2-C_{10}$  alkynyl-O-,  
 $C_3-C_{11}$  cycloalkyl-O-,  
15  $C_3-C_{10}$  cycloalkenyl-O-,  
 $C_1-C_6$  alkyl- $C_6-C_{12}$  aryl-O-,  
 $C_6-C_{10}$  aryl- $C_1-C_6$  alkyl-O-,  
 $C_1-C_6$  alkyl-het-O-,  
het- $C_6-C_{10}$  alkyl-O-,  
20  $C_6-C_{12}$  aryl-O-,  
 $C_1-C_{10}$  alkyl-NR<sup>n</sup>-,  
 $C_2-C_{10}$  alkenyl-NR<sup>n</sup>-,  
 $C_2-C_{10}$  alkynyl-NR<sup>n</sup>-,  
 $C_3-C_{11}$  cycloalkyl-NR<sup>n</sup>-,  
25  $C_3-C_{10}$  cycloalkenyl-NR<sup>n</sup>-,  
 $C_1-C_6$  alkyl- $C_6-C_{12}$  aryl-NR<sup>n</sup>-,



- 5        het, where the substituents on any alkyl, alkenyl or alkynyl are 1-3  $R^a$  and the substituents on any aryl or het are 1-3  $R^d$ ;

$R^d$  are independently selected from the group

OH,



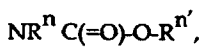
- 10        halo(F, Cl, Br, I),



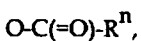
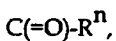
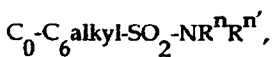
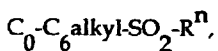
cyano,



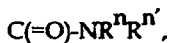
- 15         $SOR^n$ ,



- 20         $NR^nC(=O)-R^{n'}$ ,

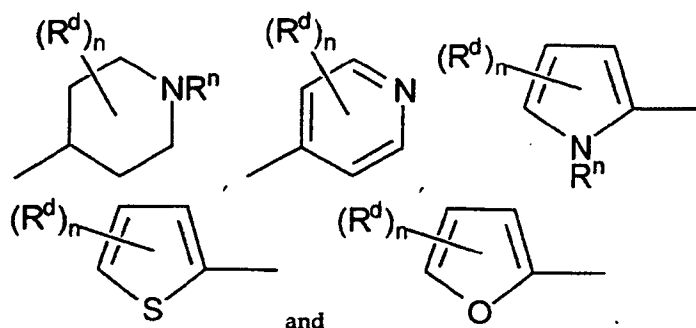


- 25         $C(=O)-O-R^n$  and



het is selected from the group





$R^n$  and  $R^{n'}$  are independently selected from the group

hydrogen,

hydroxyl,

$C_1-C_6$  alkyl and

halo(F, Cl, Br, I)- $C_1-C_6$  alkyl;

halo is selected from the group F and Cl;

$Z^1$  is selected from the group  $NR^n$ , O and S;

n is 0-3; and

pharmaceutically acceptable salts thereof.

9) The method of Claim 6 wherein the adhesion receptor is selected from LFA-1 (CD11a/CD18) and Mac-1 (CD11b/CD18).

10) The method of Claim 9 wherein the adhesion receptor is LFA-1.

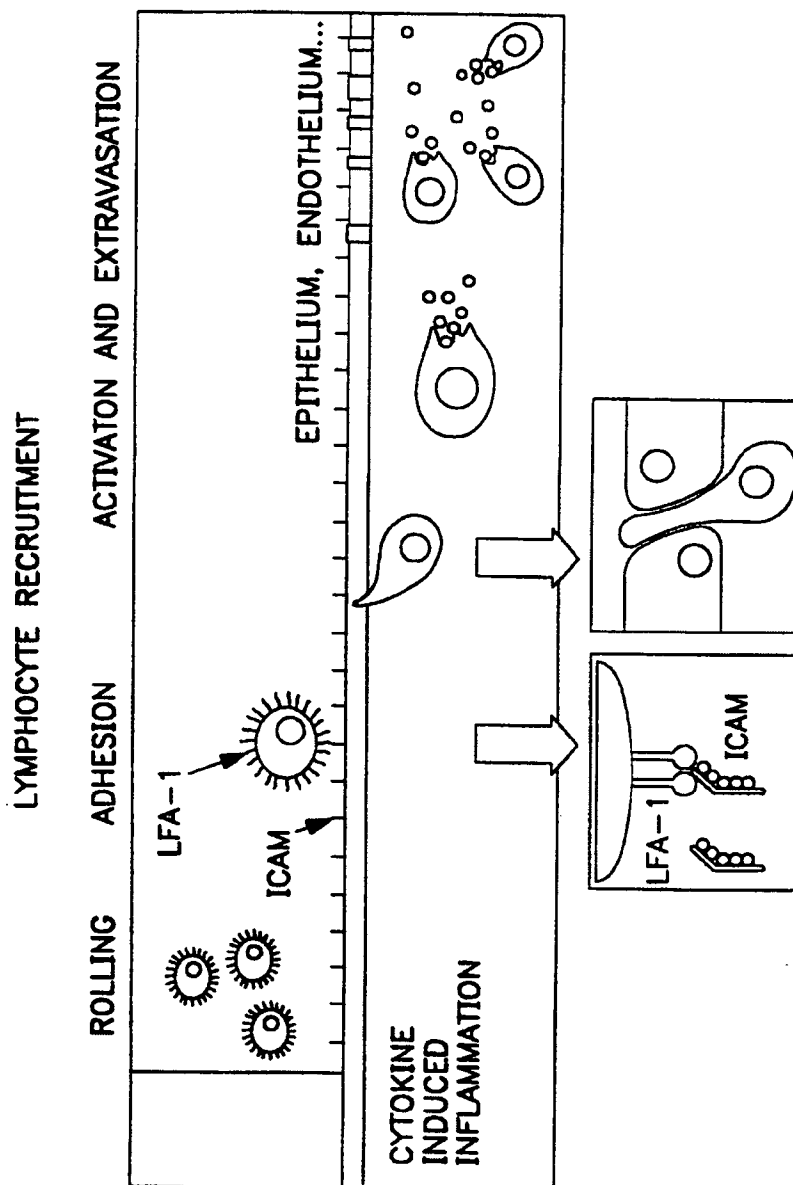
11) The method of Claim 6 wherein the immune disorder is selected from the group; rejection of or by a transplanted graft, psoriasis, rheumatoid arthritis, asthma and multiple sclerosis.

12) The method of Claim 6 further comprising administering an effective amount of an immunosuppressive agent to the mammal.

13) The method of Claim 6 further comprising administering an effective amount of a VLA-4 antagonist to the mammal.

14) The method of Claim 10 wherein the disorder is selected from psoriasis and asthma and the therapeutically effective amount of the LFA-1 antagonist is administered orally, topically, transdermally, inter-pulmonary or inter-nasal.

15) The method of Claim 6 wherein the mammal is a human.

**FIG. 1**

## Human ICAM-1:LFA-1 Receptor Binding Assay

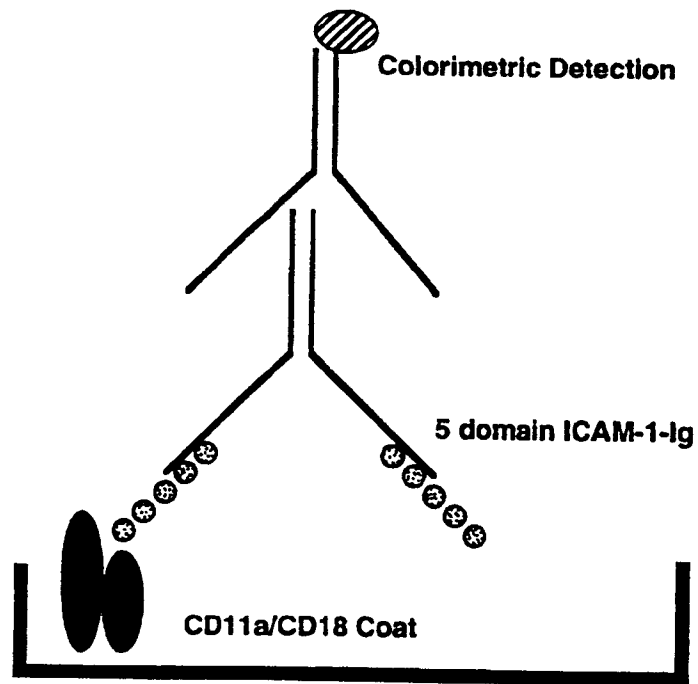


FIG. 2

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## Human T-cell Adhesion Assay

Colorimetric Detection

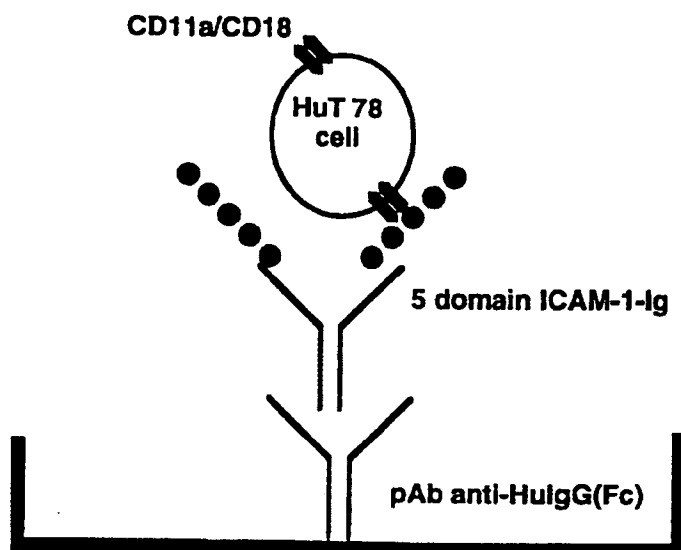


FIG. 3

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# Human One Way Mixed Lymphocyte Response

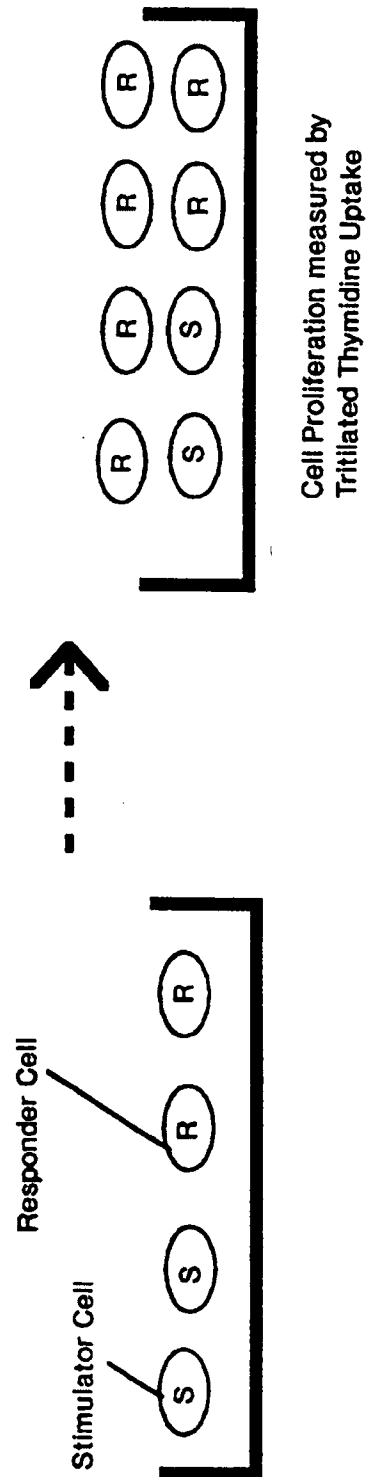
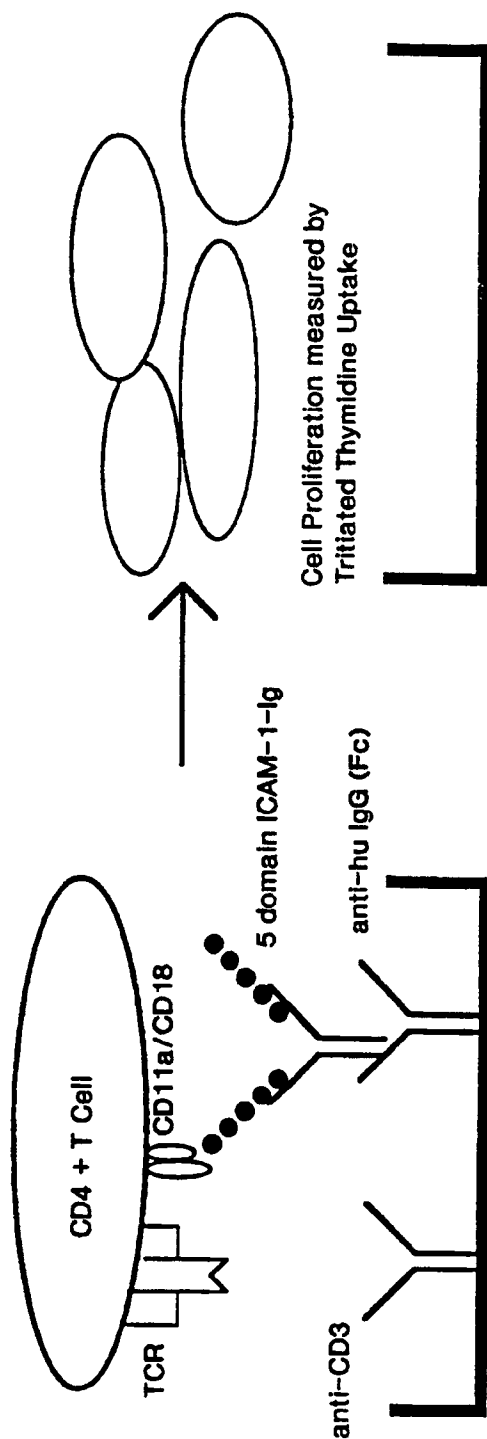


FIG. 4

5/ 5



Coat anti-Fc 2 ug/ml & anti-CD3 .07ug/ml overnight  
(50 ul ea.)

Capture 5dICAM-Ig 17 ng/ml (100ul)

Culture 72 hours, pulse cells last 6 hours

FIG. 5

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